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CONTENTS:

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*ADDRESS OF THE PRESIDENT BEFORE THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.**

THE time-honored custom of our Association makes it incumbent upon the retiring President to deliver an address upon some subject connected, if possible, with his own work, and not purely elementary or historical, but with at least some fresh ideas and some new facts. The task is a difficult one for a chemist, for there is perhaps no branch of science in which, of late years, there has been so much mental activity, and it is hard to find any subject which has not been worn threadbare in discussion.

Trusting to your indulgence, I will here present some theoretical points connected in part with my own work, and will treat them as briefly as the nature of the subjects will permit.

All chemists are familiar with the terms atom and molecule. The use of these two words, with a clear conception of their meaning, forms an era in the history of the science. Our modern chemistry is built up of atoms and molecules, as we now define them. Our modern physics deals for the most part and, as I think, too exclusively with atoms, except, perhaps, in the case of what we now term physical chemistry, the new branch of science, which makes it difficult for us to determine where chemistry

*Delivered before the Boston meeting, August 22, 1898.

leaves off and where physics begins. The old controversy between the advocates of the continuity and those of the discontinuity of matter is not dead, but only sleeps.

It must be admitted that the conception of the atom, as at present received, is not without serious objections, and probably many accept it as presenting fewer difficulties than the theory of continuity. I venture to suggest that the idea of a material limit, like that of space or quantity in mathematics, avoids at least some difficulties, so that we may define an atom as a limit to which we approach as we subdivide a given mass of any element, having reference to properties alone. Or, taking a somewhat different mathematical conception, we may consider atoms as material differentials of which the general integrals which we term masses are made up, and in this way we may connect purely material with purely mathematical conceptions. The conception of a limit or of a differential avoids all hypotheses as regards form as well as regards magnitude, and retains only ideas of mass and kind. Conversely, I doubt whether, for the purpose of instruction in the calculus, any purely mathematical conception of limits or of differentials and integrals gives as clear an idea of these as does the comparison with physical or chemical atoms and their aggregates.

As all chemists know, we owe to Dalton the first clear conception of the chemical atom as distinguished from the atoms of Leucippus and Democritus ; to Frankland the conception of valence which shows us what combinations of atoms can exist consistently with the number of units of affinity possessed by each individual atom, or, in other words, in what manner groups of atoms can form systems which are in stable equilibrium. This conception includes that of the chemistry of space, now so much employed in organic chemistry, as well as that of the motions of atoms within the molecule, as yet almost without supporters. To the conception of a definite number of units of affinity recent chemistry has added that of direction of action, statical according to one school of chemists, dynamical according to another.

Within a comparatively short time attention has been directed to a large class of compounds exhibiting very interesting properties and forming peculiar series, some of which, at least, are made up of homologous terms. This group has been called complex-inorganic, because many of its members form highly complex molecules of which no analogues are known.

I may here remark that Ostwald uses the term 'complex' to denote only those molecules or groups of associated atoms which are unitary and do not belong to the class of double salts. I have not drawn this distinction in the present paper, because it is not that which was originally proposed, and because at present we are not able to separate the two classes from each other, except in a very limited number of cases.

No one class of compounds appears so well adapted to throw light upon the structure and modes of combination of molecules. For this reason I have selected the group as the subject of my address to-day.

In endeavoring to establish a plausible theory of the constitution of the complex-inorganic acids and their salts it will be advantageous to state first succinctly the principal facts to be explained. These, I think, are as follows :

1. The teroxides of molybdenum and tungsten possess, in a remarkable degree, what may be termed a 'cumulative' character, each being capable of forming series of salts which contain a very large relative number of molecules of the teroxide. In this respect they stand alone, so far at least as our present knowledge extends. Certain other oxides share in this peculiarity to a

much less degree, as, for example, chromic and perhaps uranic oxides.

I will cite, in the first place, the series of metatungstates, the existence of which has, I believe, been fully established, partly by the researches of other chemists and partly by those made in my own laboratory.

The first term in the series has the general formula $RO.4WO_3$; the highest appears to be represented by the formula $11 RO.24WO_3$. These, with the intermediate compounds, form a series of homologous terms, the common difference being $RO.2 WO_3$.

Molybdenum forms a similar, but, in the present state of our knowledge, not so fully represented series. Moreover, in this case, it seems necessary to assume that certain metamolybdates contain a greater or less number of molecules of water as base, either partly or wholly replacing fixed oxides. In my first paper I have discussed this subject, and may here refer to that paper for necessary details. A revision of the composition of the alkaline molybdates is much to be desired, taking specially into account the number of molecules of water retained at high temperatures.

I may here remark that my views in regard to the existence of special classes of metatungstates and metamolybdates have not only not found acceptance with other chemists, but, so far as I know, have never even attracted attention

2. Two different metatungstates may unite to form a double salt, as, for instance,

$$12WO_3.5MO + 10WO_3.4MO + 66H_2O$$
$$12WO_3.5Na_2O + 10WO_3.4Na_2O + 51H_2O.$$

Such compounds, however, are not numerous, and it is possible to explain their structure in other ways. Similar molybdates have not been observed, except in cases in which other oxides, as, for instance, platinic oxide, are present.

3. Metatungstates and metamolybdates may react with a great variety of other salts to form complex salts in which a relatively very large number of molecules of tungstic or molybdic oxides appear, as compared with the number of molecules of the combined salt or oxide.

4. Metatungstates or metamolybdates may unite with complex salts containing tungstic or molybdic oxides, as, for example,

$$10WO_3PtO_24Na_2O + 2\{10WO_34Na_2O\} + 72H_2O.$$

5. Complex acids in the molecule which is united with the tungstic or molybdic oxide appear not to lose their special characters and, in many cases, though not in all, to retain their basicity. Thus in the phospho-tungstate $12WO_3PO_4H_3$ the phosphoric acid is still ortho-phosphoric acid. Two different oxides, acids or salts may unite with tungstic or molybdic oxide, each retaining it own character. I will cite only the phosphoroso-phospho tungstate.

$$24WO_32PO_3H_3P_2O_55K_2O + 13H_2O$$

and the arsenoso-phospho-tungstate

$$32WO_3.14As_2O_3.3P_2O_510K_2O + 28H_2O.$$

Classes of salts have been described in which ortho-phosphoric, hypo-phosphorous, phosphorous, pyro-phosphoric, mono-metaphosphoric and hexa-metaphosphoric molecules appear as such.

The first of the formulas above given may be written

$$22WO_3P_2O_52K_2O.H_2O + 12\,WO_3.2POK_3 + 16\,H_2O$$

and will represent a quadruple salt if each term is to be considered as representing a double salt.

6. In the great majority of cases the number of molecules of water in the meta-salts as well as in their derivatives is extraordinariiy large, but in the present state of our knowledge we are unable to distinguish with certainty between water of constitution and water of crystallization.

In considering the theory of the complex inorganic acids it will be most advantageous to begin with the group of silico-tungstates discovered by Marignac. Of these there are four classes, two of which are isomeric. We may write the general formulas of the neutral salts as follows, omitting water of crystallization :

$10\ WO_3.SiO_2.4RO$ $10\ WO_3.SiO_2.2RO.2H_2O$
$11\ WO_3.SiO_3.4\ RO$
$\begin{cases} 12\ WO_3.SiO_2.4RO \quad 12\ WO_3.SiO_2 2RO.2H_2O \\ 12\ WO_3.SiO_2.4\ RO \end{cases}$

It is, of course, possible that the second group, containing eleven molecules of tungstic oxide, may have twice the molecular mass given, so that the general formula is:

$$12\ WO_3.SiO_2.4RO+10\ WO_3.SiO_2 4RO$$

The potassic salt, which is the only one described by Marignac, will then be the analogue of the double sodium and zinc metatungstate, which I have described, and which has, at least probably, the formula:

$$12\ WO_3.5Na_2O+10WO_3 4ZnO$$

Taking now the first series or group, the general term may be written in one of several ways, as, for example :

(1) $10WO_3.SiO_2(RO)_4$
(2) $10WO_3.RO+SiO_2(RO)_3$
(3) $10WO_3 2RO+SiO_2(RO)_2$
(4) $10WO_3 3RO+SiO_2 RO$
(5) $10WO_3 4RO+SiO_2$

Formulas (1) and (2) appear to be excluded by the fact that silicates of the forms $SiO_2(RO)_4$ and $SiO_2(RO)_3$ are not known to exist, the only forms of silicic acid occurring in silicates containing a single base, in other words, in single as distinguished from double salts, being metasilicic acid SiO_3H_2 and ortho-silicic acid SiO_4H_4 or SiO_2H_2O and $SiO_2 2H_2O$ or corresponding salts. On the other hand, formulas (3) and (4) are admissible so far as the silica is concerned, but considered as double salts they require us to assume the existence of $10\ WO_3 2RO$ and $10\ WO_3 3RO$, which are not known to exist. Formula (5) is also admissible, if we suppose that a molecule of water is present, and thus we have $10\ WO_3.4RO+SiO_2OH_2$.

Marignac considered all the acids of this series as quadribasic and consequently that two molecules of basic water were present in each of a number of well defined salts.

From the above it appears difficult to explain the constitution of the various silico-tungstates and tungsto-silicates if we consider them as simply double salts. We must assume either that tungstates not known to exist or that silicates which have no analogues or that both these classes enter together into the structure of the complex molecules.

We get no assistance from a consideration of the mode of preparation of the complex salts in question. Marignac obtained them by boiling gelatinous silica with metatungstates. Gelatinous silica has no definite constitution, but appears to be simply a mixture of two or more forms of silicic acid. It has not been shown, I believe, that soluble alkaline silicates dissolve tungstic oxide on boiling, but Parmentier found that silicomolybdates are formed by the action of alkaline silicates upon alkaline molybdates in presence of silicic acid, and Pechard has shown that a silico-molybdate of the twelve molecule series is formed by the action of fluosilicic acid upon the 14:6 metamolybdate of ammonium.

The same reasoning applies to the silicotungstates and tungsto-silicates, which contain twelve molecules of tungstic oxide, since the last named classes of acids also unite with four molecules of base.

In this connection three remarkable double salts deserve notice. These have respectively the formulas:

$36WO_3.3SiO_2.2Al_2O_3 + 93H_2O$ and $+ 81H_2O$
$36WO_3 3SiO_2.2Al_2O_3(NH_4)_2O + 75H_2O$
$36WO_3.3SiO_2.2MO_5.8Na_2O + 45H_2O$.

These salts may all be considered as containing three molecules of the complex:

$$12WO_3.SiO_2.$$

The two first may be, respectively:

$2(Al_2O_3 3H_2O) + 3(WO_3SiO_2 4H_2O) + 75H_2O$
$2(Al_2O.3H_2O)$
$+ 2(12WO_2SiO_2.3(NH_4)_2OH_2O + 63H_2O$

and the third:

$2(N_2O_5Na_2O) + 3(12WO_3SiO_2 2Na_2O2H_2O)$
$+ 39H_2O$.

The following also deserve notice in the same connection:

$12WO_3SiO_2 3K_2O.H_2O$
$+ 12WO_3SiO_2.2K_2O_3 2H_2O + 26H_2O$.
$12WO_3SiO_2.3CaO.H_2O$
$+ 12WO_3SiO_2.2CaO.2H_2O + 46H_2O$.

The simplest view which can be taken of all these compounds is that they contain the complex $12WO_3.Sio_2.4RO$ and that they are double and not quadruple salts or acids. And it seems to me that the weight of evidence is in favor of the view that the complex $WO_3SiO_2.4RO$ or $10WO_3SiO_2.4RO$ is single or unitary and not a double salt of a tungstate and silicate.

Marignac did not attempt to explain the isomerism of silico-tungstic and tungsto-silicic acids, and the problem is one of much interest, since there are no allotropic modifications of tungsten or silicon.

To obtain a further insight into the constitution of the simpler complex acids we may, with advantage, also consider the cases of the phosphotungstates and phosphomolybdates. As normal we may take the acids $12WO_3.PO_4H_3$ or $12MoO_3.PO_4H_3$. These correspond to the twelve molecule silico tungstates or tungsto-silicates of Marignac, and the reasoning applied to these cases will apply also to the phosphotungstates and phosphomolybdates. Only in these last the number of known compounds is much greater, acids in which the proportion of tungstic or molybdic oxide to phosphoric oxide is as 24:1, 22:1, 20:1, 18:1, 16:1, 5:1, being known in their corresponding salts. Besides these we have arsenic compounds in which the ratio of tungstic or molybdic oxide to arsenic oxide is as 6:1 and 7:1, as well as double salts in the ordinary acceptation of the term. Instances of these last are:

(1) $22MoO_3.P_2O_5.3K_2O$
$+ 22MoO_3.P_2O_5.2K_2O.H_2O + 21 H_2O$.
(2) $2(20MoO_3.P_2O_5.3(NH_4)20)$
$+ 20MoO_3.P_2O_5.2(NH_4)_2O.H_2O + 11 H_2O$.
(3) $24MoO_3P_2O_5.3(NH_4)_2O$
$+ (24MoO_3.P_2O_5.2(NH_4)_2O.H_2O + 16 H_2O$.

Upon any other than the view which I have taken the phosphotungstates and phosphomolybdates of the types $nWO_3P_2O_5 6RO$ and $nMo_3.P_2O_5 6RO$ are salts *sui generis* analogous to metatungstates and metamolybdates. The compounds expressed by these last formulas are quaternary.

We may compare these salts (1), (2) and (3) with the double tungstate

$$12 WO_3 5Na_2O + 10 WO_3.4Na_2O + 51 \text{ aq}.$$

They behave like salts of meta-tungstates or meta-molybdates which have taken into their structure molecules of phosphoric or arsenic oxides without materially changing their general character. The precise mode of combination of the tungstic and molybdic molecular masses with silica, phosphoric or arsenic oxides is not at present known, but it is not difficult to show that the units of affinity of all the elements present may be accounted for and illustrated by structural diagrams. In like manner, the condensation of n molecules of tungstic or molybdic teroxide is easily explained, the number of unsaturated or residual units of affinity

being for all values of n equal to 2, as in the case of water.*

The study of the complex acids which contain ortho-phosphoric acid as such naturally led to that of complex acids containing other acids of phosphorus. The greater number, or at least the more important, of these have been shown to give well-defined complex acids, and in all cases appeared to contain the phosphorus compound in the modification in which it existed before the combination with tungstic or molybdic oxide. Since this work was completed several new acids containing phosphorus have been discovered, more especially the so-called hypo-phosphoric acid, and it is to be hoped that these also will be studied from the same point of view. I shall ask attention to the compounds now known. The only pyrophospho-tungstates yet observed belong to the general types for the acids

$$(22WO_3.9P_2O_7H_4)\ 2RO.$$

and for the salts

$$(22WO_3.9P_2O_7R_2.)\ 2RO.$$

The salts containing molybdic teroxide differ from the above and belong to different types. All those which were examined contained manganous oxide and all contained but two molecules of pyrophosphoric acid or corresponding pyrophosphates in place of nine. It is not easy to see how the presence of manganous oxide as base can affect the formation of such salts, but the analyses of a pyrophospho-tungstate containing six molecules of manganous oxide correspond very closely to a formula embraced under the type

$$14WO_3.6RO + P_2O_7R'_4.$$

so that, so far as the empirical constitution is concerned, the salt may be regarded as double and as containing two salts belonging to well known types. In the present state of our knowledge it seems more probable that the pyrophospho-tungstates and pyrophospho-molybdates are double salts belonging to the second class of complex inorganic salts. The solutions of the alkaline salts give, with solutions of the heavy metals, precipitates which contain only pyrophosphoric acid and neither tungsten nor molybdenum. On the other hand, it is well worthy of notice that the group

$$9(P_2O_7R_4)$$

is capable of existing independently of tungstic oxide. Wallroth has shown that we have salts of the type

$$(P_2O_7)_9R''_{10}Ne_{16}.$$

Of the other modifications of phosphoric acid I shall notice only the mono-metaphosphates and the hexa-metaphosphates. In the case of the former the type of the tungsten compounds is:

$$(mWO_3.2PO_3R)pR'O.$$

As in the case of the pyrophospho-tungstates we have here to distinguish an internal and an external basicity, the group $(mWO_3.2PO_3R)$ standing in the relation of a complex oxide to the external group $pR'O$. For the mono-meta-phosphomolybdates the type is different:

$$(m'MoO_34PO_3R)p'R'O$$

and, of course, other types are possible. So far as we can now judge the salts containing mono-meta-phosphoric acid belong to the first group like phosphotungstates and phosphomolybdates of the type

$$12WO_3.PO_4R_3 \text{ and } 12MoO_3PO_4R_3.$$

They give no reactions characteristic of their constituents, but the precipitates which they form with metallic salts have the oily or pasty character of the salts of metaphosphoric acid.

The only hexa-metaphosphomolybdate examined has the formula

*See *American Journal of Science and Arts*, Vol. XLIV., November, 1867.

$$(14MoO_3.6PO_3Ba_3)BaO + 55\ H_2O.$$

and we may safely infer that the type is

$$(mMoO_3.6PO_3R_3)pRO,$$

there being an internal and external basicity, as in the cases above noted.

It is worthy of note that in all the known acids containing phosphorus in some oxidized form other than orthophosphoric acid the number of molecules of the acid united to tungstic or molybdic oxide is greater than in the ortho-phosphotungstates or ortho-phosphomolybdates containing an equal number of molecules of tungstic or molybdic oxides.

Two classes of phosphorus compounds remain to be considered—those which contain phosphorous and those which contain hypophosphorous acid or corresponding salts. Chemists are not wholly agreed as to the rational constitution of either of these acids, but it is perhaps more probable that the phosphorous molecule is represented by the formula

$$\{H.PO(OH)_2\}$$

and the hypophosphorous molecule by the formula

$$\{H_2PO.OH\}.$$

The typical formula for salts containing the former is

$$mWO_3.n\{H.PO(OR)_2pR'O$$

or

$$m'MoO_3.n'\{H.PO(OR)_2p'R'O.$$

and for those which contain the hypo-phosphorous molecule

$$mWO_3n\{H_2PO.OR\}pRO$$

$$m'MoO_3n'\{H_2PO.OR\}p'R'O$$

Both groups of salts appear to belong to the first class of complex acids or salts. It is worthy of notice that the phosphorous and hypo-phosphorous salts do not reduce copper from its solutions even on boiling, and they can, therefore, hardly be supposed to be simply double salts in the ordinary acceptation of the term.

We owe to Blomstrand the discovery of a specially remarkable and interesting class of complex acids, the molybdo-periodates or, in the notation which is more commonly used, periodo-molybdates. The acid of this series has the formula :

$$12MoO_3.I_2O_7.5H_2O.$$

and is the analogue of phosphomolybdic acid.

$$24MoO_3.P_2O_5.3H_2O.$$

The salts of this series are 5-basic, but, as in the case of metatungstates and metamolybdates, these are composed of two or more normal salts. The best defined of these has the formula :

$$(12MoO_3.I_2O_7.5K_2O)$$
$$+ (12MoO_3I_2O_7.2K_2O.3H_2O) + 30\ H_2O.$$

which we may compare with

$$(24MoO_3.P_2O_53(NH_4)_2O)$$
$$+ (24MoO_3.P_2O_5.2(NH_4)_2O.H_2O)16\ H_2O.$$

In the complex acids, of which the present paper treats, we may consider the teroxides of tungsten and molybdenum as the determinants. Oxides, of which SiO_2, P_2O, R_2O_8 and I_2O_7 may serve as types, may be regarded as sub-determinants. The chemical potential of the compound will, of course, be a function of the chemical potentials of both determinants and sub-determinants. Protoxides appear not to form sub-determinants, but in all cases to act simply as bases. One of the difficulties of our subject consists in determining how far the sub-determinants proper may act as bases, and especially whether they are not sometimes partly bases and partly sub-determinants in the same salt.

In my published paper I have made two assumptions as regards the rôle of vanadic pentoxide in the vanadio-tungstates and vanadio-molybdates.

The first is that $V_2O_2.O_3$ may replace WO_3 so that chemically

$$mWO_3 + n(V_2O_2)O_3$$

may act as a whole; the second that V_2O_5 may form combinations with a number of molecules of tungstic or molybdic teroxide analogous to phosphotungstates or phosphomolybdates. These assumptions, taken separately or together as the case may require, in many cases at least reduce complex to simple formulas perfectly comparable to those of salts containing phosphoric or arsenic pentoxide. Thus we have

$$5WO_3.V_2O_5.4(NH_4)_2O.2H_2O + 11H_2O.$$
$$5MoO_3.V_2O_5.3(NH_4)_2O.3H_2O + 4H_2O \text{ and}$$
$$8MoO_3.V_2O_5.3BaO + 8MoO_3.2BaO.H_2O.$$

In addition I have described two vanadiotungstic acids having respectively the formulas:

$$10WO_3.V_2O_5.6H_2O + 16\ H_2O.$$
$$18WO_3V_2O_5.6H_2O + 30\ H_2O.$$

The existence of these compounds has been denied,* but I see no sufficient reason for rejecting the formulas, which at least closely correspond to the analyses. The same remark applies to the acid

$$20V_2O_5.P_2O_5.6H_2O + 53\ H_2O.$$

or

$$20V_2O_2O_3.P_2O_5.6H_2O + 53\ H_2O.$$

which I would compare with

$$20WO_3.P_2O_5.6H_2O.$$

It must be admitted, however, that in view of the extraordinary number and variety of the combinations of vanadic pentoxide with bases it cannot be denied that there are very numerous compounds of this oxide with the teroxides of tungsten and molybdenum, which, in the present state of our knowledge, must be classed as double salts. The empirical composition of these salts may be expressed by the general formula:

$$mWO_3.nV_2O_5.pRO$$

or

$$m'Mo_3n'V_2O_5p'RO.$$

in which m, m′ represent respectively the number of molecules of tungsten or molybdenum and n, n′, p, p′ are whole numbers. Friedheim assumes that in many of these compounds vanadic pentoxide acts as a base and that in others mixtures of isomorphous salts are present. The pentoxide dissolves readily in the stronger acids, as, for instance, in sulphuric and phosphoric acids, but I am not aware that well defined crystalline salts of this oxide have been obtained. There are also, I believe, no known instances of isomorphism between tungstic and vanadic or molybdic and vanadic oxides. In spite, therefore, of all that has been done, it seems necessary to admit that our knowledge of the vanadio-tungstates and vanadiomolybdates is still very imperfect, but this remark applies also to the very large group of alkaline vanadates.* Of course, the theory that in the salts in question we are dealing, chiefly at least, with double salts is that which would naturally present itself first, but we meet with the difficulty that the constituents of these double salts are themselves double salts, so that we must deal in fact with triple and quadruple salts.

In my view the acids or salts which are usually termed complex may be divided into two classes.

Class first embraces those in which the union of the determinant and sub-determinant is so complete that the special characters of the constituents are nearly or wholly lost. The salts of this class are not decomposed by solution. They may be compared to certain so-called double cyanides, as, for example, to ferrocyanides and cobalticyanides. The acids $12\ WO_3.PO_4H_3$ and $12\ MoO_3.PO_4H_3$ are examples.

Class second embraces double salts proper which are decomposed by solution alone and which contain two different constituents. Salts of this class are very numerous, and there are probably various sub-classes.

*See Friedheim. Berichte, Band XXIII., p. 1505 and 1530 (and Rosenheim Dissertation, Berlin, 1888); Zeitschrift für amorgan. Chemie, Band V., p. 437; Berichte, Band 24, p. 1173.

*See Proceedings of Am. Acad., Vol. XVIII., p. 74.

In the present state of our knowledge it is not possible for us to assign to more than a few acids the classes to which they belong, and a vast field of chemico-physical work is open to the investigation of this subject alone.

We have also to determine by methods now well known to chemists the molecular masses of metatungstates and metamolybdates and of the complex inorganic acids, which may be considered as derived from, or at least as definitely related to them. Certain double salts appear to be composed of metatungstates or metamolybdates united to salts containing subdeterminants, as, for instance, and more especially, platinic oxide. I may, for the sake of clearness, refer to such formulas as

$$10\,WO_3.4Na_2O + 10\,WO_3.PtO_2.5Na_2O + 58aq.$$

and

$$4\{12MoO_3.2K_2O.3H_2O\} + \{12MoO_3.PtO_2.2K_2O.4H_2O\} + 24aq.$$

These salts appear not to be decomposed by water and to belong therefore to class first.

The compounds of arsenic oxide with tungstic and molybdic oxides closely resemble those of phosphoric oxide and do not now require special notice as regards their structure and properties, nor as to the question of their position as unitary or double salts.

On the other hand, the salts which contain arsenious oxide present some special points of interest, since this oxide exhibits distinct basic and, in its salts, distinct acid properties. The general formulas for this class of compounds, so far as they have been studied, are

$$mWO_3.nAs_2O_3.pRO \text{ and } m'MoO_3n'As_2O_3.p'RO$$

As characteristic salts we may take the arsenoso-molybdates

$$6MoO_3.3As_2O_3.2RO$$

of which four have been obtained in fine crystals.

The copper and nickel salts of this type have a fine green color and, therefore, contain the two metals as ions, at least in part. It is, therefore, most probable that the salts are unitary. This view is supported by the fact that the alkaline salts from which the salts of manganese, copper, zinc and nickel are obtained by double decomposition give reactions which are different from those of the constituent molybdic and arsenious oxides. The same statement applies to other known arsenoso-molybdates and to arsenoso-tungstates.

I pass over without notice a number of interesting salts, some of which contain for a single determinant at least three different sub-determinants, as, for example, phosphoric and vanadic pentoxides and vanadic dioxide. We are only at the beginning of our knowledge of these compounds. From their extreme complexity it would seem most probable that they belong to the second class and are in some cases double, triple or quadruple salts, of which possibly the components may belong to the first class. Long and laborious investigations are required, sure to be rewarded by an abundant harvest of new facts, of little or no practical value perhaps, but to be looked at from the higher point of view of pure abstract knowledge.

The term 'complex inorganic' was at first intended to embrace all the compounds containing a relatively large number of molecules of tungstic and molybdic oxides as determinants, beginning with the silicotungstates of Marignac. Hittorf, in 1859, appears to have first drawn the distinction between double salts which are decomposed by solution and those which are stable under the same circumstances. Finally, Ostwald proposed to restrict the term 'complex' to the salts which are not decomposed by solution and which gave none of the chemical reactions of the constituents.

Of these two classes it is difficult to say

which is the more interesting and theoretically important. The salts of the first class are comparatively new to chemists, and, in spite of all which has been done, offer a very wide field for investigation. Those of the second class present new species of double and even of triple and quadruple salts. It will first be necessary to study the whole subject by physical as well as by the purely chemical methods which all chemists have hitherto employed, so as to define as distinctly as possible the limit, if there be one, which separates the two classes from each other. I make the point that all known methods of distinguishing double from unitary salts should be employed in each case, as I believe it has not yet been satisfactorily shown that all these methods give coincident results. It seems also possible that there may exist between the two classes given a third class, the salts belonging to which exhibit intermediate properties. In chemistry, as in other branches of science, sharply defined boundaries between groups are the exception. I am not aware that the chief methods of distinguishing between single and double salts have been brought together for reference, and perhaps the following list may be convenient:

1. Purely chemical or reaction tests.
2. Decomposition by solution alone.
3. Physical methods.
   a. Determination of the electric conducting power of dilute solutions.
   b. Determination of the ions by electrolysis and by spectroscopic observations.
   c. Observation of the change of temperature in the formation of the complex salt. Heat is evolved in the formation of a complex salt from unitary molecules; none in the formation of a double salt. The formation of a complex salt, therefore, is accompanied by a loss of energy.

Other methods have been given, but the above mentioned will suffice for most purposes.

In the brief and elementary sketch which I have given to-day of two large and important classes of salts I have avoided the use of the so-called structural, or, as they should be termed, valence formulas. That such formulas are often useful, if only as checks upon purely speculative work, cannot be doubted. But it seems to me that the time has come for wider and more general conceptions of the chemical action between masses, subject perhaps to the fundamental idea of valence and yet not too dependent upon this idea as at present received. In a paper published long since, an attempt was made to extend the atomistic conception and to maintain the theory that the action of one complex mass upon another is determined by the residual unsaturated units of affinity present, without reference to the number of units due to each atomic mass. I venture now to suggest that, in addition to its valence, each atom and each molecule possesses a special chemical potential, not necessarily a function of its valence. The expression 'chemical potential' is not wholly new, but I think the conception has never been clearly defined. I would now define it as bearing the same relation to chemical action which the electric potential bears to electrical action, the two potentials being mutually convertible, all chemical compounds having residual affinities or potentials besides the valencies. If we suppose that the atoms within the molecule are in motion, such motion will be independent of the valences and the molecule will have a certain amount of free kinetic energy convertible into chemical electrical energy or into heat.

In inorganic chemistry four great problems now present themselves for solution. These are:

The existence and chemical relations of the gaseous elements, of which five are known to exist in the atmosphere. The separation of the elements forming the rare earths, by systematic processes and the determination of their positions in the periodic

series; the thorough and, so far as possible, exhaustive study of the complex and double salts and, finally, the determination of the atomic masses of the elements with all the precision of which the subject admits, and in the spirit of Stas, of Richards and of Morley.

WOLCOTT GIBBS.

A HALF-CENTURY OF EVOLUTION, WITH SPECIAL REFERENCE TO THE EFFECTS OF GEOLOGICAL CHANGES ON ANIMAL LIFE.*

ONLY a little less than fifty years have passed since the publication of Darwin's Origin of Species, and the general acceptance by naturalists of the theory of descent. Since 1848 the sciences of embryology, cytology and comparative anatomy based on embryology, or, as it is now called, morphology, have been placed on a firm foundation. It is but little over half a century since the uniformitarian views of Lyell were promulgated. The cell doctrine was born in 1839; the view that protoplasm forms the basis of life was generally received forty years since; fifty years ago the doctrine of the conservation of forces was worked out, and already by this time had the idea of the unity of nature dominated the world of science.

On the fiftieth anniversary, therefore, of our Association, it may not be out of place, during the hour before us, first, briefly to inquire into the present state of evolution and its usefulness to zoologists as a working theory, and then to dwell more at length on the subject of the effect of geological changes on animal life.

The two leading problems which confront us as zoologists are: What is life? and How did living beings originate? We must leave to coming centuries the solution of the first question, if it can ever be solved; but we can, as regards the second, congratulate ourselves that, thanks to Lamarck, Darwin and others, in our day and generation, a reasonable and generally accepted solution has been reached.

Time will not allow us to attempt to review the discoveries and opinions which have already been discussed by the founders and leaders of the different schools of evolutionary thought, and which have become the common property of biologists, and are rapidly permeating the world's literature.

It may be observed at the outset that, if there is any single feature which differentiates the second from the first half of this century, it is the general acceptance of the truth of epigenetic evolution as opposed to the preformation or incasement theory, which lingered on and survived until a late date in the first half of the present century.*

*Address of the Vice-President before Section F.—Zoology—of the American Association for the Advancement of Science, August 22, 1898.

*The theory of incasement (*emboîtment*), propounded by Swammerdam in 1733, was that the form of the larva, pupa and imago of the insects pre-existed in the egg, and even in the ovary, and that the insects in these stages were distinct animals contained one inside the other, like a nest of boxes, or a series of envelopes one within the other; or, in his own words: "*Animal in animali, seu papilio intra erucam reconditus.*" Réaumur (1734) also believed that the caterpillar contained the form of the chrysalis and butterfly, saying: "Les parties des papillon cachées sous le fourreau de chenille sont d'autant plus faciles à trouver que la transformation est plus proche. Elles y sont neanmoins de tout temps." He also believed in the simultaneous existence of two distinct beings in the insect. "Il serait très curieux de connaître toutes les communications intimes qui sont entre la chenille et le papillon. * * * La chenille hache, broye, digere les aliments qu'elle distribué au papillon; comme les mères préparent ceux qui sont portés aux fœtus. Notre chenille en un mot est destineé à nourrir et à defendre le papillon qu'elle renferme." (Tome i, 8e Mémoire, p. 363.)

It was not until 1815 that Herold exploded this error, though Kirby and Spence in 1828, in their Introduction to Entomology, combated Herold's views and maintained that Swammerdam was right. As late as 1834, a century after Swammerdam, Lacordaire, in his Introduction à l'Entomologie, declared that 'a caterpillar is not a simple animal, but compound,' and he actually goes so far as to say that 'a

The establishment of the epigenetic view is largely due to exact investigation and modern methods of research, but more especially to the results of modern embryology and to the fairly well digested facts we now have relating to the development of one or more types of each class of the animal kingdom.

To use a current phrase, the evolution theory as now held has come to stay. It is the one indispensable instrument on which the biologist must rely in doing his work.

caterpillar, at first scarcely as large as a bit of thread, contains its own teguments threefold and even eightfold in number, besides the case of a chrysalis, and a complete butterfly, all lying one inside the other.' This view, however, we find is not original with Lacordaire, but was borrowed from Kirby and Spence without acknowledgment. These authors, in their Introduction to Entomology (1828), combated Herold's views and stoutly maintained the old opinions of Swammerdam. They based their opinions on the fact, then known, that certain parts of the imago occur in the caterpillar. On the other hand, Herold denied that the successive skins of the pupa and imago existed as germs, holding that they are formed successively from the '*rete mucosum*,' which we suppose to be the hypodermis of later authors. In a slight degree the Swammerdam, Kirby and Spence doctrine was correct, as the imago does arise from germs, *i. e.*, the imaginal disks of Weismann, while this was not discovered by Herold, though they do at the outset arise from the hypodermis, his *rete mucosum*. Thus there was a grain of truth in the Swammerdam, Kirby and Spence doctrine, and also a mixture of truth and error in the opinions of Herold.

The discovery by Weismann of the imaginal discs or buds of the imago in the maggot of the fly, and his theory of histolysis, or of the more or less complete destruction of the larval organs by a gradual process, and his observation of the process of building up of the body of the imago from the previously latent larval buds, was one of the triumphs of modern biology. It is, therefore, not a little strange to see him at the present day advocating a return to the preformation views of the last century in the matter of heredity. Of course, it goes without saying, as has always been recognized, that there is something in the constitution of one egg which predestines its becoming an insect, and in that of another which destines it to produce a chick.

It is now almost an axiomatic truth that evolution is the leaven which has leavened the whole lump of human intellectual activity. It is not too much to claim that evolutionary views, the study of origins, of the beginning of organic life, the genesis of mental phenomena, of social institutions, of the cultural stages of different peoples and of their art, philosophy and religion—that this method of natural science has transformed and illuminated the philosophy of the present half-century.*

It is naturally a matter of satisfaction and pride to us as zoologists that, though evolution has been in the air from the days of the Greek philosophers down to the time of Lamarck, the modern views as to the origin of variations, of adaptation, of the struggle for existence, of competition, and the preservation of favored organs or species by selection, are the products of single-minded zoologists like Darwin, Wallace, Fritz Müller, Semper and Haeckel. It is

* It is worthy of mention that just fifty years ago in his 'Future of Science,' written in 1848, at the age of 25, Renan, who perhaps first among philosophers and students of comparative philology adopted the scientific method, *i. e.*, the patient investigation of as wide a range of facts as possible, wrote: "I am convinced that there is a science of the origins of mankind and that it will be constructed one day, not by abstract speculation, but by scientific researches. What human life in the actual condition of science would suffice to explore all the sides of this single problem? And still, how can it be resolved without the scientific study of the positive data? And if it be not resolved how can we say that we know man and mankind? He who would contribute to the solution of this problem, even by a very imperfect essay, would do more for philosophy than by half a century of metaphysical meditation" (p. 150). Again he says: "The great progress of modern thought has been the substitution of the category of *evolution* for the category of the '*being;*' of the conception of the relative for the conception of the absolute, of movement for immobility. Formerly everything was considered as 'being' (an accomplished fact); people spoke of law, of religion, of politics, of poetry in an absolute fashion. At present everything is considered as in the process of formation" (p. 169).

the work of these men, supplemented by the labors of Spencer and of Huxley, and the powerful influence of the botanists Hooker and Gray, all of whom contributed their life-long toil and efforts in laying the foundation stones of the theory, which has brought about its general acceptance among thinking men. It is these naturalists, some of them happily still living, who have worked out the principle of evolution from the generalized to the specialized, from the simple to the complex, from chaos to cosmos.

The doctrine of evolution has been firmly established on a scientific basis by many workers in all departments of biology, and found not only to withstand criticism from every quarter, but to be an indispensable tool for the investigator. The strongest proof of its genuine value as a working theory is that it has, under the light shed by it, opened up many an avenue of inquiry leading into new fields of research. It is based on the inductive method, the observation and arrangement of a wide series of facts. Moreover, it explains a vast complex of facts, and enables us to make predictions, the true test of a scientific theory. Biology is not an exact science, hence the theory is not capable of demonstration like a problem in mathematics, but is based on probabilities, the circumstantial evidence being apparently convincing to every candid, well-trained mind.

The methods and results of natural science, based as they now are on evolutional grounds, have, likewise, appealed to the historian, the philologist, the sociologist, and the student of comparative religion, whose labors begin with investigations into the origins.

It goes without saying that, thanks to the initiative of the above-named zoologists, every department of intellectual work and thought has been rejuvenated and rehabilitated by the employment of the modern scientific method. All inquiring minds appreciate the fact that, throughout the whole realm of nature, inorganic, as well as organic, physical, mental, moral and spiritual, there was once a beginning, and that from a germ, by a gradual process of differentiation or specialization, the complex fabric of creation has, by the operation of natural laws and forces, been brought into being. All progress is dependent on this evolutionary principle, which involves variation, adaptation, the disuse or rejection of the unfit, the use or survival of the fittest, together with the mechanical principle of the utmost economy of material.

Though the human mind has its limitations, and the chief arguments for evolution have been drawn from our observations of the history of our own planet, and of the life existing upon it, the nebular hypothesis teaches us that the same process has dedetermined the origin of other worlds than ours and applies in fact to all the other members of our solar system, while with little doubt the principles may be extended to the entire universe.

At all events, evolutionary methods of thinking have now become a second nature with philosophic, synthetic minds, and to such any other view is inconceivable. We teach evolution in our colleges and universities, and the time is rapidly approaching, and in some instances has already come, when nature studies, and the facts of biology forming the grounds of the evolutionary idea, will be taught in our primary and secondary schools.

The rapidity with which evolutionary conceptions have taken root and spread may be compared to the rankness of growth of a prepotent plant or animal on being introduced into a new territory where it is free from competition. It has, indeed, swept everything before it, occupying a field of thought which hitherto had been unworked by human intelligence.

The immediate effect, and a very happy

one, of the acceptance of the theory of descent on working zoologists is to broaden their minds. Collectors of insects and shells, or of birds and mammals, instead of being content simply to acquire specimens for their cabinets, are led to look during their field excursions for examples of protective mimicry, or to notice facts bearing on the immediate cause of variation. Instead of a single pair of specimens, it is now realized that hundreds and even thousands collected from stations and habitats wide apart are none too many for the study of variation as now pursued.

The race of 'species grinders' is diminishing, and the study of geographical distribution, based as it is on past geographical changes and extinctions, is now discussed in a far more philosophical way than in the past. The most special results of work in cytology and morphology are now affording material for broad work in phylogeny and heredity.

On the other hand, it must be confessed that, as the result of the acceptance of evolutionary views, our literature is at times flooded with more or less unsound hypotheses, some tedious verbiage and long-winded, aërial discussions, based rather on assumptions than on facts. But on the whole, perhaps, this is a healthy sign. Too free, exuberant growths will be in the long run lopped off by criticism.

One tendency should be avoided by younger students, that of too early specialization, and of empirical work without a broad survey of the whole field. In some cases our histologists and morphologists rise little above the intellectual level of species describers. Expert in the use of the microtome and of reagents, they appear to have but little more general scientific or literary culture than high-class mechanics. The chief antidote, however, to the danger of narrowness is the lessons derived from evolutionary thought and principles.

Finally, as a proof of the value of evolutionary ideas to the present generation, let us suppose for a moment, if it were conceivable, that they should be blotted out. The result, it is safe to say, would be equivalent to the loss of a sense.

It is a matter of history that when a new idea or principle, or a new movement in philosophy or religion, arises it at first develops along the line of least resistance; the leaders of the new thought acquire many followers or disciples. Soon the latter outstrip their teachers, and go to greater extremes; modifications of the original simple condition or theory occur, and as the final result there arise schisms and differentiations into new sects. This has happened in science, and already we have evolutionists divided into Lamarckians and Darwinians, with a further subdivision of them into Neolamarckians and Neodarwinians, while the latter are often denominated Weismannians. Some prefer to rely on the action of the primary factors of evolution; others believe that natural selection embraces all the necessary factors, while still others are thoroughly persuaded of its inadequacy.

The result of this analytical or differentiating process will probably be an ultimate synthesis, a belief that there is a complex of factors at work. Of these factors those originally indicated by Lamarck, with the supplementary ones of competition and natural selection bequeathed by Darwin, are the most essential and indispensable, and it is difficult to see how they can be displaced by other views. Meanwhile all agree, and it was never more firmly established than at this moment, that there is, and always has been, unceasing energy, movement and variation, a wonderful adaptation and harmony in nature, between living beings and their surroundings.

The present status of evolution in its different phases or attitudes since the time of

the appearance of Darwin's Origin of Species may be roughly pointed out as follows:

1. The claim by some thinkers of the inadequacy of Darwinism, as such, or Natural Selection, to account for the rise of new species, and the assignment of this factor to what they believe to be its proper place among the other factors of organic evolution.

2. The renascence of Lamarckism under the name of Neolamarckism, being Lamarckism in its modern form. This school relies on the primary factors of evolution, on changes in the environment, such as the agency of the air, light, heat, cold, changes in climate, use and disuse, isolation, and parasitism, while it regards natural, sexual, physiological, germinal and organic selection, competition or its absence, and the inheritance of characters acquired during the lifetime of the individual, as secondary factors, calling into question the adequacy of natural selection as an initial factor.

3. The rise of the Neodarwinian school. While Darwin, soon after the publication of the Origin of Species, somewhat changed his views as to the adequacy of natural selection, and favored changes in the surroundings, food, etc., as causes of variation, his successors, Wallace, Weismann and others, believe in the 'all-sufficiency' of natural selection. Weismann also invokes panmixia, or the absence of natural selection, as an important factor; also amixia, and denies the principle of inheritance of acquired characters, or use-inheritance.

4. A third school or sect has arisen under the leadership of Weismann, who advocates what is in its essence apparently a revival of the exploded preformation, encasement or 'evolution' theory of Swammerdam, Bonnet and Haller, as opposed to the epigenetic evolutionism of Harvey, Wolff, Baer and the majority of modern embryologists. On the other hand, there are some embryologists who appear to accept the combined action of epigenesis and evolution in development.

5. Attention has been concentrated on the study of variations and of their cause. Opinion is divided as to whether variation is fortuitous or definite and determined. Many now take exception to the view, originally held by Darwin, that variations are purposeless and fortuitous, believing that they are, for example, dependent on changes in the environment which were determined in early geological periods. For definite variations Eimer proposes the term orthogenesis. Minute variations dependent on climatic and other obscure and not readily appreciable causes are now brought out clearly by a system of varied and careful quantitative measurements.

6. More attention than formerly is given to the study of dynamical evolution, or kinetogenesis; to the effect of external stimuli, such as intermittent pressure, mechanical stresses and tensions by the muscles, etc., on hard parts. Originally suggested by Herbert Spencer, that the ultimate cause or mechanical genesis of the segmentation of the vertebrate skeleton was due to transverse strains, the segmentation of the bodies of worms and arthropods, as well as of vertebrates, has been discussed by recent workers (Rider, Cope, Meyer, Tornier, Hirsch and others.) Here should be mentioned the work done in general physiology, or morphogenesis, by Verworn, Davenport and others. Also the discoveries of Pasteur, and the application by Metschnikoff and of Kowalevsky of phagocytosis to the destruction and renewal of tissues during metamorphosis, bear closely on evolutional problems.

7. A new field of research, founded by Semper, Vilmorin and Plateau, and carried on by DeVarigny, is that of experimental evolution, involving the effects of artificial changes of the medium, including temperature, food, variation in the volume of water

and of air, absence of exercise, movement, etc. Also should be added horticultural experiments which have been practised for many years, as well as the results of acclimatization.

Here should be mentioned the experiments bearing on the mechanics of development (Entwickelungsmechanik der Organismen), or experimental embryology, of Oscar Hertwig, Roux, Driesch, Morgan and others, and the curious results of animal grafting and of mutilations of the embryos, obtained by Born and others, as well as the regeneration of parts. The remarkable facts of adaptation to new and unfavorable conditions of certain embryos are as yet unexplained, and have led to considerable discussion and research.

8. The *a priori* speculations of Darwin, Galton, Spencer, Jaeger, Nusbaum, Weismann and others, based on the results of the labors of morphologists and cytologists, have laid the foundation for a theory of the physical basis of heredity, and for the supposition that the chromatine in the nucleus of reproductive cells is the bearer of heredity. The theory has already led to prolonged discussions and opened up new lines of work in cytology and embryology.

9. The subject of instinct, discussed from an evolutional point of view, both by morphologists and psychologists, particularly by Lloyd Morgan, has come to the front, while mental evolution has been discussed by Romanes and others.

With all these theories before us, these currents and counter-currents in evolutional thought bearing us rapidly along, at times perhaps carrying us somewhat out of our depth, the conclusion of the whole matter is that in the present state of zoology it will be wise to suspend our judgment on many theoretical matters, to wait for more light and to confine our attention meanwhile to the observation and registration of facts, to careful experiments and to repeated tests of mere theoretical assumptions.

Meanwhile we may congratulate ourselves that we have been born and permitted to labor in this nineteenth century, the century which in zoological science has given us the best years of Lamarck's life, a Cuvier, a Darwin, a Von Baer, an Owen, an Agassiz, a Haeckel, a Spencer, and a Huxley—the founders of modern zoology—who have sketched out the grander features of our science so completely that it will, perhaps, be the work of many coming years to fill in the details.

GEOLOGICAL CAUSES OF VARIATION AND OF THE EXTINCTION AND RENEWAL OF SPECIES.

The most immediate and efficient cause of variation appears to be changes of environment or of the physical conditions of existence. These, besides the agencies of gravity, electricity, of the atmosphere, light, heat, cold, food, etc., comprise geological changes or revolutions in the topography of the earth's surface at different periods. The latter causes appear to have had much to do with the process of extinction and renewal of plants and animals.

While the doctrine of the effect on animals of a change of environment was suggested very early in this century and forms the corner stone of Lamarckism, Wallace was, after De la Beche,* and especially Lyell†, the first in recent times, in an essay published in 1855, to call attention to this subject thus:

"To discover," he says, "how the extinct species have from time to time been replaced by new ones down to the very latest geological period, is the most difficult, and

*Researches in Theoretical Geology. New York, 1837, p. 217. Quoted by Woodworth, p. 220.

† Principles of Geology, 1830–1832.

at the same time the most interesting, problem in the natural history of the earth." *

Still more recently † he remarks:

"Whenever the physical or organic conditions change to however small an extent, some corresponding change will be produced in the flora and fauna, since, considering the severe struggle for existence and the complex relations of the various organisms, it is hardly possible that the change should not be beneficial to some species and hurtful to others."

Two conclusions are now generally accepted. The first is, that the most complete evidence of evolution is afforded by paleontology. Huxley's vigorous affirmation, that the primary and direct evidence in favor of evolution can be furnished only by paleontology, has been greatly strengthened by recent discoveries. The second is that biological evolution has been primarily dependent on physical and geological changes.

It may not be unprofitable for us as zoologists to pass in review some of the revolutions in geological history, particularly as regards our own continent, some important details of which have recently been worked out by our geologists, and to note the intimate relation between these revolutions and the origination not only of new species, but of new faunæ, and, indeed, at certain epochs, of new types of organic life.

1. *Precambrian revolutions.* That immensely long period which intervened between the time when our planet had cooled down and become fitted for the existence of animal life, and the opening of the Cambrian period, was evidently a time of the geologically rapid production of ordinal and class types of invertebrate life. This is strongly suggested by the fact that a large proportion of the Cambrian classes embrace forms as highly specialized as their successors of the present day, so that we are compelled to look many ages back of the Cambrian for the appearance of their generalized ancestral forms.

* Natural Selection, p. 14.

† Darwinism, 1889, p. 115.

Of the eight branches, of phyla, of the animal kingdom, the remains of seven, or all except the vertebrates, have been found in Cambrian strata. Adopting the kind of statistics employed by Professor H. S. Williams in his admirable Geological Biology, but with some changes necessitated by a little different view as to the number of classes living at the beginning of the Cambrian period, it appears that 13 out of 26 classes of the animal kingdom, occurring in a fossil condition, already existed in the Cambrian and, if we throw out from the vertebrate classes those without a solid skeleton (the Enteropneusta or Balanoglossus, Tunicates, Amphioxus and the lampreys) 13 out of 22. Also, if we exclude the land forms (Arachnida, Myriopoda and insects), 13 out of 19, and then throwing out the five vertebrate classes found in a fossil state, of 14 invertebrate marine classes 13 occur in the Cambrian.* With little doubt flat-worms, nemerteans, Nematelminthes and Gephyrea existed then, and probably the representatives of other classes, of which no traces will ever occur.

We shall for our present purpose follow the classification of the U. S. Geological Survey and restrict what was formerly called the Archean to the fundamental gneiss and crystalline schists of an unknown thickness, and accept the Algonkian, as comprising the Huronian and Keeweenawan formations. We may assume that the first beginnings of life took place toward the end of the Archean and that the more or less rapid differentiation of class types went on during Algonkian time. This view is fortified by the statement of Wal-

* Should the Polyzoa be traced to the Cambrian, as is not at all impossible, the fact would remain that every class of marine invertebrates with solid parts is represented in the Cambrian.

cott that a great orographic movement, followed by long-continued erosion, took place between the Archean and Algonkian ages.

Taking as an example of the nature of the Algonkian changes one region alone, the Lake Superior region, where the stratigraphical record is more complete, we have: 1, the Lower Huronian schists, limestone, quartzites, conglomerates, etc., with their eruptives, closely folded and attaining a maximum thickness of probably over 5,000 feet.

2. The Upper Huronian, unconformable to the Lower, a series of more gently folded schists, slates, quartzites, conglomerates, interbedded and cut by trap, with a maximum thickness of 12,000 feet. In the Animikie quartzites of this age have, according to Selwyn, been detected a track of organic origin, in the Minnesota quartzites Lingula-like forms, as well as obscure "trilobitic-looking impressions; while carbonaceous shales are abundant."

3. Between these Huronian rocks and the true Cambrian series are interpolated the Keweenawan clastic rocks, with a maximum thickness of 50,000 feet. Though these beds are by some high authorities referred to the Cambrian, the fact remains that this series, whether Cambrian or Algonkian, is unconformable to the Huronian, and composed of fragmental rocks, the upper division being 15,000 feet thick, and consisting wholly of detrital material largely derived from the volcanoes of the same series. Between each series is an unconformity representing an interval of time long enough for the land to have been raised above the seas, for the rocks to be folded, to have lost by erosion thousands of feet, and for the land to sink below the surface of the ocean.

Again, between the Precambrian and Cambrian there was, according to Walcott, a great uplift and folding of rock, succeeded by long-sustained erosion, over all the continental area. It was not, however, he states, 'as profound as the one preceding Algonkian time, as is proved by the more highly contorted and disturbed Archean rocks beneath the relatively less disturbed Algonkian series.' *

The evidence of the existence of life-forms in the Huronian and Keweenawan times is indicated by the presence of thick beds of graphitic limestone, beds of iron carbonates, and by a great thickness of carbonaceous shales, which are represented by graphitic schists in the more altered strata. In the Animikie rocks on the northern shores of Lake Superior, Ingalls finds abundant carbon, and it is said that in certain mines and openings rock-gas forms to a considerable extent. Also small quantities of rock may even be obtained which will burn. "These substances must result from the ordinary processes which produce rock-gas and coal in the rocks of far later age. The hydrocarbons which occur so abundantly in the slightly metamorphosed shales of the Huronian about Lake Superior must be of organic origin," and, if so, the graphitic schists of the same system "are in all probability only those hydrocarbonaceous shales in a more altered condition."

As to the fossils actually detected in what are by some geologists regarded as Algonkian strata, Winchell has detected a Lingula-like shell in the pipestones of Minnesota. Selwyn has described traces of animals in the Upper Huronian of Lake Superior. Murray, Howley and Walcott have discovered several low types in the Huronian of Newfoundland; *i. e.*, a mollusc (*Aspidella terranovica*)† and traces of a worm (*Aren-*

* The North American Continent during Cambrian Time. Twelfth Ann. Rep. U. S. Geological Survey, p. 544.

†Dr. G. F. Matthew writes me as follows regarding this supposed fossil: "I have seen *Aspidella terranovica* in the museum at Ottawa and doubt its organic origin. It seems to me a slickensided mud-

icolites spiralis), the latter said to occur in the primordial rocks of Sweden. Walcott reports the discovery, in the Grand Cañon of the Colorado, of the following Precambrian fossils: "A minute discinoid or patelloid shell, a small Lingula-like shell, a species of Hyolithus, and a fragment of what appears to have been the pleural lobe of the segment of a trilobite belonging to a genus allied to the genus *Olenellus*, *Olenoides*, or *Paradoxides*. There is also an obscure *Stromatopora*-like form that may not be organic.

Here should be noted the discovery, in 1896, of *Radiolaria** in calcareous and cherty rocks of 'undoubted Precambrian age' near Adelaide, Australia (*Nature*, Dec. 24, 1896, p. 192); the detection of fossils in the Archean of Brittany, and of three veins of anthracite 'in crystalline schists of Archean age' in Ecuador.

At St. John, New Brunswick, that able and experienced geologist, Dr. G. F. Matthew, has detected fossils in strata which he refers to the upper Laurentian. They occur in three horizons. The lowest series is composed of a quartzite containing fragments of the skeleton of hexactinellid sponges allied to Cyathospongia. In the upper limestone of the second horizon were collected calcareous coral-like structures resembling *Stromatopora rugosa*. In the third and uppermost horizon, consisting of beds of graphite, occurred great numbers of spicules of apparently hexactinellid sponges. "Between this upper Laurentian system and the basal Cambrian occurs," says Matthew, "a third system, the Coldbrook and Coastal, Huronian, which has given conglomerates to the Cambrian and has a great thickness." He also tells us that the Precambrian St. Etcheminian beds at St. John, consisting of red and green slates and shales, have a meagre fauna comprising Protozoa, brachiopods, echinoderms, molluscs, with plentiful worm burrows and trails. In commenting on this subject Sir J. W. Dawson remarks that these Etcheminian strata rest on Huronian rocks which, near Hastings, Ontario, contain worm burrows, sponge-spicules, 'and laminated forms comparable to Cryptozoon and Eozoon.' (*Nature*, Oct. 15, 1896, p. 585.)

Even allowing room for error in the correlation of these formations, and in regarding some of these rocks as no older than Cambrian, yet on the whole the result appears to be that abundant vegetation existed in Precambrian times, which was converted into graphite, while representatives of seven classes were perhaps already in existence previous to the Cambrian period.

The following lists give a comparative view of the classes of the periods in question:

Precambrian Classes.	*Cambrian Classes.*
Rhizopoda (Radiolaria).	Rhizopoda (Foraminifera and Radiolaria).
Porifera (Hexactinellid Sponges).	Porifera (Sponges).
	Hydrozoa (Meduse and Graptolites).
Actinozoa (Corals).	Actinozoa (Corals).
Brachiopoda.	Brachiopoda.
Annelida.	Annelida.
	Crinoidea.
	Asteroidea.
	Lamellibranchiata.
Mollusca.	Gastropoda (including Pteropoda*).
	? Cephalopoda (Orthoceras ?).
Trilobita.	Trilobita.
	Crustacea.

concretion striated by pressure. I have found similar objects in the Etcheminian olive gray beds below the St. John group."

*Dr. Matthew likewise informs me: "The (*Radiolarian?*) rocks of Adelaide, South Australia, Mr. Howchin writes to me he now finds to be Lower Cambrian. He has found Archæocyathus in them; but this is not proof of *Lowest* Cambrian, as the genus is found in the *Paradoxides* beds of the south of France."

* Dr. Matthew writes me that he doubts if Hyalithoid shells should be referred to Pteropoda. "Pelseneer quite repudiates them; and to me their heavy shells, and frequent habitat on rough shores, do not speak of the fragile Pteropoda."

It would seem from these data that the physical condition of the sea and atmosphere was favorable to the existence of types for aught we know quite or nearly as highly specialized as those of the same classes now in existence. Life and nature in the Precambrian went on, so far as we can tell, much as in Cambrian times. Though locally there are breaks in the continuity of geological processes, yet probably over the world generally there was a continuity of geological phenomena, and on the whole a tolerably unbroken series of organic forms.

It is obvious, however, that in the regions thus far examined, the Precambrian, whether we include the Archean or not, more than at any time since, though the land areas are by some considered to be of small extent, was a period of widespread and profound changes in the distribution of land and sea. While it is generally supposed that the extent of the continental areas at the beginning of Paleozoic time was small, forming islands, Walcott is inclined to the belief that it was very considerable, stating:

"The continent was larger at the beginning of the Cambrian period than during any epoch of Paleozoic time, and probably not until the development of the great fresh-water lakes of the Lower Mesozoic was there such a broad expanse of land between the continental platform between the Atlantic and Pacific Oceans. The agencies of erosion were wearing away the surface of this Algonkian continent and its outlaying mountain barriers to the eastward and westward, when the epoch of the Lower Cambrian or Olenellus zone began. The continent was not then new. On the contrary, it was approaching the base level of erosion over large portions of its surface. The present Appalachian system of mountains was outlined by a high and broad range, or system of ranges, that extended from the present site of Alabama to Canada, and subparallel ranges formed the margins of basins and straits to the east and northeast of the northern Paleo-Appalachian or the Paleo-Green Mountains, and their northern extension toward the Precambrian shore-line of Labrador. The Paleo-Adirondacks joined the main portion of the continent, and the strait between them and the Paleo-Green Mountains opened to the north into the Paleo-St. Lawrence Gulf, and to the south extended far along the western side of the mountains and the eastern margin of the continental mass to the sea that carried the fauna of the Olenellus epoch around to the Paleo-Rocky Mountain trough." (*l. c.* p. 562.)

Remarking on the habitat, or nature and extent of the sea-bottom tenanted by the Olenellus or Lower Cambrian fauna, Walcott remarks:

"One of the most important conclusions is that the fauna lived on the eastern and western shores of a continent that, in its general configuration, rudely outlines the North American continent of to-day. Strictly speaking the fauna did not live upon the outer shore facing the ocean, but on the shores of interior seas, straits, or lagoons that occupied the intervals between the several ridges that rose from the continental platform east and west of the main continental land surface of the time." (*l. c.* p. 556.)

Dana had previously (1890) claimed that the earth's features even to many minor details were defined in Archean time (evidently referring to all Precambrian time) and that 'Archean conditions exercised a special and even detailed control over future continental growth.' May not this idea be extended to include the life of the Precambrian, and may we not suppose that biological variations and evolutions were predetermined to some degree at least by the geological conditions of these primeval ages? The continental masses were then

foreshadowed by submarine plateaus covered by shallow seas, the deeper portions of the ocean basins not being affected by these oscillations, extensive as they were.

The time which elapsed between the end of the Laurentian and the beginning of the Cambrian was immense, or at least as long as the entire Paleozoic era. Walcott estimates the length of the Algonkian at 17,500,000 years. This length of time, or even a portion of it, was long enough for the origination and establishment of those classes, whose highly specialized descendants flourished in the Cambrian. Referring to the Precambrian strata Walcott states :

"That the life in the pre-Olenellus seas was large and varied there can be little, if any, doubt. The few traces known of it prove little of its character, but they prove that life existed in a period far preceding Lower Cambrian time, and they foster the hope that it is only a question of search and favorable conditions to discover it." *

Here the imagination of the zoologist may be allowed for the moment free scope to act. It is perhaps not hazardous to surmise that in the early centuries or millenniums of the Huronian there arose, from some aggregated or compound infusorian, the prototype of the sponges.

From some primitive gastrula which became fixed to the Huronian sea-bottom may have arisen the hydroid ancestor of the Cœlenterates ; owing to its fixed mode of life, the primitive digestive cavity opened upwards, being held in place by the septa, so that the vase-shaped body, growing like a plant, with the light striking upon it from all sides, assumed a radical symmetry. Before the beginning of the Cambrian, for we know Aurelia-like forms abounded on the Cambrian coasts, medusæ budded out from some hydroid polyps, became free-swimming, and as a result of their living at the surface became transparent, and thus shielded from the observation of whatever enemies they had, multiplied in great numbers.

From some reptant gastræa there may have sprung, in these primeval times, an initial form with a fore-and-aft, dorso-ventral and bilateral symmetry, which gave origin by divergent lines of specialization to flat-worms, nemertean and round-worms, as well as Rotifera, and other forms included among the Vermes. It is probable that the Trematodes and Cestodes, especially the latter, whose organs have undergone such reduction by parasitism, and some of which through disuse have totally disappeared, did not evolve until some time after the appearance of molluscs and fishes.

When existence in these early plastic vermian forms was confined to boring in the mud and silt, the body became cylindrical, as in some nemerteans, and in the thread-worms ; some of the latter forms, boring into the mud, became parasites, entering the bodies of other animals which serve as their hosts.

At about this time certain worms, as the simple mechanical result perhaps of threading their way over or through the rough gravelly bottom, became segmented. The establishment of a segmental structure, brought about by the serpentine mode of progression in the direction of least resistance, resulted in the origination of a succession of levers. Following this annulated division of the dermo-muscular tube of worms, was the serial or segmental arrangement of the internal organs, *i. e.*, the nervous, excretory, reproductive and glandular, and, in a less degree, the circulatory.

In certain of these primitive protannelids, as the result perhaps of external stimuli intermittently applied, bristles originated to aid in progression, and finally the segmentally arranged lateral flaps of the

* The fauna of the Lower Cambrian or Olenellus zone. Tenth Annual Report of the U. S. Geological Survey, 1888–89.

skin, the parapodia, which served as swimming organs. Other nepionic forms, at first free swimming, became fixed and protected by two valves as in the Brachiopoda, which owe their success in Precambrian times to to their fixed and protected bodies.

Not long after the annelid type became established that of the echinoderms apparently diverged from some nepionic worm, like a trochosphere. In such a form there was a tendency to the deposition of particles and plates of lime in the walls of the body, and the type, becoming fixed at the bottom, or at least nearly stationary, and meanwhile more or less protected by a calcareous armor, lost its originally bilateral and acquired a radial symmetry.

But no echinoderms have yet been detected in Percambrian rocks, which, however, have revealed arthropods, as shown by the traces of trilobites, and this tends to indicate that radial symmetry is an acquired, not a primitive characteristic.

At this time was solved the problem of the origination of a type of body, and of supports for it either in walking or in swimming, which should fulfill the most varied conditions of life, and this type, the arthropodan, as events proved, was that fitted for walking over the sea-bottom, for swimming or for terrestrial locomotion; nor was the idea of segmentation both in trunk and limbs discarded when the type culminated in flying forms—the insects.

The Arthropoda, as the record shows, first represented by trilobites, which structurally are nearer the annelids than Crustacea, was destined to far outnumber in individuals, species, orders and classes any other phylum. Fundamentally worm-like or annelid in structure, the body consisted of a linear series of stiff levers, and was supported by limbs segmented in the same way. The variations of the arthropodan theme are greater than in any other groups, and nature, so to speak, succeeded most admirably in this type, with the exception of the Trilobita, which was the first class of the phylum to appear and the first to disappear. The evolution of jointed limbs was accomplished in the most economical and direct way. The parapodia were perhaps utilized, and at first retaining their form in swimming phyllopods, afterwards from being used as supports, became cylindrical and jointed. All this modification of monotypic forms and evolution from them to other types was accomplished not very late perhaps in the Precambrian. After the specialization of the antennæ and of the trunk-segments of the trilobites was worked out, all the postantennal appendages being alike, there ensued in some descendant of another vermian ancestor a further differentiation of the postantennal appendages into mandibles, maxillæ, maxillipedes, thoracic ambulatory legs, and abdominal swimming feet, as worked out in the more specialized members of the class of Crustacea.

As soon as the crustacean type became established, the conditions must have been most favorable for its rapid differentiation along quite divergent lines, for in the Cambrian strata occur the remains of four orders, viz., the Cirrhipedia, Ostracoda, Phyllopoda, the sole Cambrian form (*Protocaris marshi* related to the modern Apus), and the Phyllocarida. Of these the barnacles and ostracodes, with their multivalve or bivalve carapaces, are the most specialized, and in the case of the former the process of modification due to this fixed mode of life must have required ages, as must also the development of that highly modified vermian type, the Brachiopoda.

Indeed, the three lines of descent which resulted in the arthropodan phylum, as it now exists, unless there were three independent phyla, were perhaps initiated before the Cambrian. These lines are (1) the Trilobita, with their probable successors the merostomes and arachnids, (2) the

Crustacea, and (3) the myriopods and insects. Of the third line Peripatus or a Peripatus-like form was the earliest ancestor, which, of course, must have been terrestrial in habits, though its forebears may have been some fresh-water leech-like worm. We venture to state it is not wholly impossible that so composite a type as Peripatus, which bears at least some of the marks of being a persistent type, took its rise on the continental land of the Precambrian.

In the Precambrian time was also solved the problem by the molluscs of producing a spiral univalve shell; for while a large proportion of the Gastropoda were protected by patella-like shells of simple conical form, with these coexisted in the lowest Cambrian forms with spiral shells, such as Platyceras and Pleurotomaria. The comparative abundance of those highly modified molluscs, the Pteropoda, in the lowest or Olenellus Cambrian strata, strongly suggests that their diverence from the more generalized gastropod stem and their adaptation to a surface or pelagic life must have taken place long anterior to the dawn of the Cambrian.*

With them must have lived a variety of other surface forms besides Rhizopoda, whose young served as their food. The members of all classes of the Cambrian were carnivorous, feeding on the protoplasm of the bodies of microscopic animals or on the eggs and young of their own species, some living on the bottom, and others at the surface. Of marine plants of the Cambrian there are but slight traces, and it is evident that what there were were restricted to the coasts and to s allow water. The old idea that plants originally served as the basis of animal life must be discarded. As at present no plant life exists below a few fathoms, a hundred perhaps at the most, and since below these limits the ocean depths are packed with animal life which exists entirely on the young or the adults of weaker forms, so must the rise and progress of animal life have been quite independent of that of plants. The lowest plants and animals may have evolved from some common bit of protoplasm, some protist, but the evolution of the animal types became very soon vastly more complex. The specialization of parts and adaptation to the environment were more thorough and rapid in the lowest animals evidently in consequence of the greater power of locomotion, and aggressiveness in obtaining food from living organisms, and the adaptability of animal life to various oceanic conditions, especially temperature, bathymetrical conditions and a varying sea-bottom.

This rapid differentiation and multiplication of different family, ordinal and class ancestral types went on without those biological checks which operated in later times, when the seas and land masses of the globe became more crowded. There was a comparative absence of competition and selection, this being due to the lack of predaceous carnivorous forms to produce that balance in nature which afterwards existed. The two most successful and abundant types were the trilobites and brachiopods; but the former were not especially aggressive in their habits, undoubtedly taking their food in a haphazard way by burrowing in the mud or sand, having much the same kind of appendages and the same feeding habits as Limulus. The brachiopods were fixed or burrowed in the sand, straining the microscopic organisms drawn into the mouth by the currents set up through the action of their ciliated arms. The most destructive and aggressive Cam-

* Dr. Matthew has discovered at St. John, N. B., a still lower and older bed, containing no Olenellus; but Foraminifera (Orbulina and Globigerina), sponges, Pteropoda, Pelagiella which was probably an oceanic Heteropod, very primitive branchiopods, with Ostracoda and six genera of trilobites.

brian animal known to us was the Orthoceratites, but its remains have not yet been detected below the 2d Cambrian zone. Even if some protocordate Balanoglossus, Ascidians or even Amphioxus had already begun their existence in these Precambrian times they could have caused but a little more destruction of life than their contemporaneous invertebrate allies. As the remains of Ostracodermi and sharks have been detected in Trenton strata, perhaps they originated in the Cambrian, when they must have been active forces in the elimination of those Precambrian soft-bodied animals which connected classes now quite wide apart.

The rapid increase in the Precambrian population was hastened by the probable fact that this, more than any subsequent period, was one of rapid migration and colonization. Vast areas of the shallow depths over the site of the embryo continent, more or less shut off from the main ocean by shoals, reefs and islands, were, by oscillations of the sea-bottom and land, opened up at various times to migrants from the older previously settled seas.

The nature of the Precambrian sediments shows that the more open sea-bottom was swept by tidal and ocean currents varying in strength and extent. The topography of the ocean bottom over what is now land must have been more diversified than at present. In the late ages of the Algonkian, owing to active competition and the struggle for existence in the overstocked areas, the process of segregation or geographical isolation was rapidly effected, and the migrants from the denser centers of growth pressed into the then uninhabited areas where, as new, vigorous and prepotent colonists, they broke ground and founded new dynasties.

At such times as these we can easily imagine that, besides the absence of competition, the Lamarckian factors of change of surroundings bringing about new habits and thus inducing new needs, the use and disuse of organs, together with the inheritance of characters acquired during the lifetime of the individual, operated then far more rapidly and in a much more thoroughgoing way than at any period since, while all through this critical, creative period, as soon as there was a sufficient diversity in the incipient forms and structures, a selective principle began to operate.

For forty years past, since the time of Darwin, the idea that these early forms were more rapidly evolved, and that they were more plastic than forms now existing, has constantly cropped out in the writings of our more thoughtful and studious paleontologists and biologists.

Darwin, in his Origin of Species, as quoted by Walcott with approval, remarked that it is indisputable that, before the lowest Cambrian stratum was deposited, long periods elapsed, as long as, or probably far longer than, the whole interval from the Cambrian age to the present day; and that 'during these vast periods the world swarmed with living creatures.' Darwin then adds: "It is, however, probable, as Sir William Thompson insists, that the world at a very early period was subjected to more rapid and violent changes in its physical conditions than those now occurring; and such changes would have tended to induce changes at a corresponding rate in the organism which then existed."

Professor Hyatt,* from his exhaustive studies on the Nautiloidea and Ammonoidea, concludes:

"These groups originated suddenly and spread out with great rapidity, and in some cases, as in the Arietidæ of the Lower Lias, are traceable to an origin in one well-defined species, which occurs in close proximity to the whole group in the lowest bed of the

*Phylogeny of an Acquired Characteristic. Proc. Amer. Phil. Soc., XXXII., p. 371.

same formation. These facts, and the acknowledged sudden appearance of large numbers of all the distinct types of invertebrates in the Paleozoic, and of all the greater number of all existing and fossil types before the expiration of Paleozoic time, speak strongly for the quicker evolution of forms in the Paleozoic, and indicate a general law of evolution. This, we think, can be formulated as follows: *Types are evolved more quickly and exhibit greater structural differences between genetic groups of the same stock while still near the point of origin than they do subsequently. The variations or differences may take place quickly in the fundamental structural characteristics, and even the embryo may become different when in the earliest period, but subsequently only more superficial structures become subject to great variations.**

If this applies to the evolution of these cephalopods in the Mesozoic, how much more rapidly and efficaciously did the principle operate in the Precambrian period, after the initial steps in the divergence of types from the unicellular Protozoon took place? The same law or fact obtains with the insects, the eight holometabolous orders having, so far as the evidence goes, originated at nearly the same geological date, near or soon after the close of the Paleozoic era. Williams also shows, from a study of the variations of *Atrypa reticularis*, that this species in its specific characters shows a greater degree of variability of plasticity in the earlier than in the later stages of its history. We thus conclude that after the simplest protoplasmic organisms originated, the greatest difficulties in organic development, *i. e.*, the origination of the founders of the different classes were, so to speak, met and overcome in Precambrian times. The period was one of the rapid evolution of types. As Williams† has well remarked:

"The chief expansion of any type of organism takes place at a relatively early period in its life history. Since then, as with the evolution of the continent itself, the further progressive differentiation of marine invertebrate forms has, since the close of the Precambrian, been a matter of detail."

As well stated by Brooks, since the first establishment of the Cambrian bottom fauna, "evolution has resulted in the elaboration and divergent specialization of the types of structure which were already established, rather than in the production of new types."

In accepting the general truth of this statement, and its application to the marine or Cambrian types it may, however, be modified to some extent. For during the late Paleozoic was witnessed the evolution of the three tracheate, land-inhabiting, air-breathing classes of Arachnida, Myriopoda and insects, and of the air-breathing vertebrates, with limbs and lungs, comprising the four classes of amphibians, reptiles, birds and mammals.

ALPHEUS S. PACKARD.

(*To be concluded*).

*Geological Biology, p. 322.

†*L. c.* p. 347.

BOTANICAL NOTES.

ASPARAGUS RUST.

DR. B. D. HALSTED, of the New Jersey Experiment Station, has issued a bulletin No. 129) on the Asparagus Rust, its treatment and natural enemies, which is of much botanical interest, since it gives good illustrations of all the stages in natural size, and under different magnifications. This rust was described by De Candolle in 1805, and given the name which it now bears, *Puccinia asparagi*. It has been known in Europe for a long time, but was unknown in the United States before 1896. In that year Dr. Halsted detected it in New Jersey, Delaware, Long Island and some portions of New England. In 1897 and 1898 it has

spread southward and westward, but appears to be absent from the Mississippi Valley.

This bulletin is largely concerned with a discussion of the results of spraying with various fungicides. The conclusion is that spring spraying is of little if any practical value, since the reduction in the amount of rust is not proportionate to the cost of the work. Experiments are now in progress to determine whether autumn treatment by spraying or burning will be of any avail. Two natural enemies, both parasitic fungi, *Darluca filum* and *Tubercularia persicina*, have been observed the past year, 'both of which may be expected to assist materially in the checking of the ravages of the asparagus rust.'

POISONOUS PLANTS.

THE Division of Botany of the United States Department of Agriculture has issued a bulletin (No. 20), by V. K. Chesnut, upon the principal poisonous plants of the United States, which should be of the utmost use to all who have to deal with plants, from botanists and collectors to hunters and farmers. Only the plants to which attention has been particularly called are included, and it is not to be supposed that the list includes every poisonous species. Good illustrations are freely used, and in all cases general descriptions, popular names, habitat and discussions of the poisonous properties serve to render the account of the greatest value. The plants noticed are the following:

Family Agaricaceae: *Agaricus muscaria*, Fly amanita; *Agaricus phalloides*, Death Cup.

Family Melanthaceae: *Veratrum viride*, American false Hellebore.

Family Convallariaceae: *Convallaria majalis*, Lily-of-the-Valley.

Family Orchidaceae: *Cypripedium reginae*, Showy lady's slipper; *Cypripedium hirsutum*, Larger yellow lady's slipper; *Cypripedium parviflorum*, Smaller yellow lady's slipper.

Family Alsinaceae: *Agrostemma githago*, Corn cockle.

Family Ranunculaceae: *Aconitum columbianum*, Aconite; *Delphinium tricorne*, Dwarf larkspur; *Delphinium geyeri*, Larkspur; *Delphinium menziesii*, Larkspur; *Delphinium recurvatum*, Larkspur; *Delphinium trolliifolium*, Larkspur.

Family Prunaceae: *Prunus serotina*, Black cherry.

Family Cæsalpiniaceae: *Gymnocladus dioica*, Kentucky coffee tree.

Family Papilionaceae: *Astragalus mollissimus*, Woolly loco weed; *Astragalus lambertii*, Stemless loco weed; *Crotalaria sagittalis*, Rattlebox.

Family Euphorbiaceae: *Euphorbia lathyrus*, Caper spurge; *Euphorbia marginata*, Snow on the mountain.

Family Anacardiacaee: *Rhus radicans*, Poison ivy; *Rhus diversiloba*, Poison oak; *Rhus vernix*, Poison sumac.

Family Sapindaceae: *Aesculus pavia*, Red buckeye.

Family Apiaceae; *Cicuta maculata*, Water hemlock; *Cicuta vagans*, Oregon water hemlock; *Conium maculatum*, Poison hemlock.

Family Ericaceae: *Kalmia latifolia*, Broadleaf laurel; *Kalmia angustifolia*, Narrow-leaf laurel; *Rhododendron maximum*, Great laurel; *Pieris mariana*, Stagger bush; *Leucothöe catesbaei*, Branch ivy.

Family Loganiaceae: *Gelsemium sempervirens*, False jessamine.

Family Solanaceae: *Datura stramonium*, Jimson weed; *Datura tatula*, Jimson weed; *Solanum nigrum*, Black nightshade; *Solanum dulcamara*, Bittersweet; *Solanum triflorum*, Spreading nightshade.

Family Carduaceae: *Helenium autumnale*, Sneezeweed.

EDIBLE AND POISONOUS FUNGI.

ANOTHER bulletin (No. 15) from the Di-

vision of Vegetable Physiology and Pathology of the United States Department of Agriculture which will attract more than usual attention is that on 'Some Edible and Poisonous Fungi,' by Dr. W. G. Farlow, of Harvard University. In the introduction the author says: "The question which everyone asks first is: How can you tell a mushroom from a toadstool? This is one of the questions which no one can answer, unless an explanation of why the question should never be asked may be considered an answer. You cannot tell a mushroom from a toadstool, because mushrooms are toadstools. The reason why the question is so frequently asked is because the belief is well-nigh universal in this country that the fleshy umbrella-shaped fungi are divided into two classes, mushrooms, which are edible, and toadstools, which are poisonous. This assumed difference does not in fact exist. All the fleshy umbrella-shaped fungi are toadstools, and to a small number of the best-known edible forms the name mushroom is applied popularly and in commerce; but not a small number of the other toadstools are edible, and a great many of them, probably the most of them, are not poisonous."

As to how we may tell an edible from a poisonous fungus, the author says: "Our knowledge on this point is empirical. We know that certain species are edible, and others are poisonous, because people have eaten the former and found them to be good, while the latter have produced unpleasant symptoms and even death." He says further that "with regard to the species which have not been tried experimentally or accidentally we can only say that they are probably edible or poisonous, judging by their resemblance to other species known to be such. Although, in the absence of experience, analogy is the only guide, it is not a sure guide, and unpleasant surprises may arise."

The sections which follow treat of growth, structure and characteristics of toadstools, followed by descriptions and figures of *Agaricus campestris*, the common mushroom, (edible); *Amanita muscaria*, the fly Agaric (poisonous); *Amanita phalloides*, the deadly Agaric (poisonous); *Agaricus arvensis*, the horse mushroom (edible); *Hypholoma appendiculatum* (edible); *Coprinus comatus*, the horsetail fungus (edible); *Lepiota procera*, parasol fungus (edible); *Cantharellus cibarius*, chanterelle (edible); *Marasmius oreades*, fairy-ring fungus (edible); tube-bearing fungi, morels, puff-balls, etc. A half dozen rules for the use of beginners close this valuable paper. It should be in the hands of every teacher of botany, from colleges and universities down through the high schools into the grammar and primary grades.

Charles E. Bessey.
The University of Nebraska.

CURRENT NOTES ON METEOROLOGY.

REPORT OF THE CHIEF OF THE WEATHER BUREAU.

From the *Report of the Chief of the Weather Bureau for 1896–97* we learn that during the last fiscal year a total of 4,625,250 weather maps was issued, and that daily forecasts and warnings were sent to 51,694 places, by mail, telegraph, telephone, etc. There are now 81 map-printing stations outside of Washington, D. C.; about 8,000 places from which climate and crop conditions are reported, and about 3,000 voluntary observers make daily observations. The stations at which storm signals are displayed number 253. The river and rainfall stations, making daily observations to be used in river and flood forecasts, number 113 and 42 respectively. Substantial progress has been made in perfecting the kites used in the exploration of the free air, and it is hoped soon to publish daily weather charts based on the high-level readings made by means of in-

struments sent aloft on kite lines. This would be a step in advance, of the very greatest practical value in forecasting. The discussion of the data obtained by the Weather Bureau during the International Cloud Year is in the hands of Professor F. H. Bigelow, and his report is to be ready during the present year. That our Weather Bureau is carrying on a very important work, of immense value to the commercial and agricultural interests of this country, is emphatically proved by a glance at this Report. It is to be hoped that the Chief of the Weather Bureau may secure the additional appropriations which he needs in order to carry on and to extend the work under his direction.

In addition to the usual tables of meteorological data, the Report contains two monographs, *Rainfall of the United States*, by A. J. Henry, and *Floods of the Mississippi River*, by Park Morrill, already published as separate Bulletins by the Bureau.

THE MAURITIUS OBSERVATORY.

THE *Annual Report* of the Director of the Royal Alfred Observatory for the year 1896 brings official announcement of the resignation of Dr. Meldrum from the directorship of that Observatory, a position which he had held for 22 years. The work which Dr. Meldrum has done in connection with the law of storms is well known wherever meteorology is studied the world over, and meteorologists will always associate his name with that of the island in the Indian Ocean on which he lived so long and worked so indefatigably. The new Director is Mr. T. F. Claxton, F.R.A.S., whose name appears on the new volume of *Results of the Magnetical and Meteorological Observations made at the Royal Alfred Observatory, Mauritius, in the Year 1896.* This publication contains the daily, monthly and annual values of the principal meteorological elements, and the usual tables of magnetical observations.

WEST INDIAN HURRICANES.

THE Weather Bureau has recently published an important article on West Indian hurricanes by the late Father Benito Viñes, formerly Director of the Colegio de Belen, Habana. Viñes' previous monograph entitled *Apuntes relativos a los huracanes de las Antillas en Setiembre y Octobre de 1875 y 1876* is a classic. The present article was prepared by Father Viñes, shortly before his death, for the Chicago Meteorological Congress of 1893, and has been translated from the Spanish by Dr. C. Finley, of Habana, the author revising the greater part of it before his death. The title is *Investigation of the Cyclonic Circulation and the Translatory Movement of the West Indian Hurricanes.* Owing to the present interest in everything that concerns the meteorological conditions of the West Indies, the Chief of the Weather Bureau has wisely decided to give this article immediate publication, rather than to await its long-delayed appearance in the Bulletin (No. 11) which contains the papers prepared for the Chicago Congress, three parts of which have been issued, leaving the fourth still to come.

R. DEC. WARD.

HARVARD UNIVERSITY.

CURRENT NOTES ON ANTHROPOLOGY.

PYGMY TRIBE IN AMERICA.

So far as I am aware, no tribe of dwarf stature has been found in America. The Changos, of the Atacama desert, are probably the shortest. The average of the males is four feet nine inches. Of course, individual instances of dwarfs occur in many tribes, as they do among ourselves. These are due to other laws of growth than a generally diminished height.

In the *Revue* of the Paris School of Anthropology for July, Dr. Collineau

quotes a Mr. Sullivan, from our country apparently, who describes a tribe in Venezuela, on the Brazilian frontier, the males of which average four feet eight inches. The reference is too vague to admit of verification, and if some reader of SCIENCE can give further information about the statement it will be welcome to anthropologists.

THE TURANIANS AGAIN.

A FEW years ago, in European ethnography, the Mongolians reigned paramount. As Friedrich Müller said, 'Mongolian' or 'Turanian' was a sack into which all nations were thrust who could not be assigned elsewhere. Basques, Etruscans, Pelasgians, Ligurians, all were Mongolian.

For some time past there has been a lull in this mania; but in the July number of the *Revue de l'École d'Anthropologie*, Professor Herné brings forward a hypothesis surpassing in eccentricity even those previously advanced in this direction. He makes all the Celts, 'no matter in what region they may be studied,' of direct Mongolian descent. They entered Europe in the neolithic period, and brought with them a culture and a type of their own, their affinities being to-day markedly Turanian or Ural-Altaic. Surely this theory is a few years late.

THE INFLUENCE OF CITIES IN MODERN LIFE.

IN one of his thoughtful studies published in the *Correspondant* (May, 1898) the Marquis de Nadaillac discusses the concentration of the population into cities, so marked in our day. Its chief cause is undoubtedly that more money can be made and more amusement obtained in cities than in the country.

In cities the mortality is greater, the natality less, than in the country. Marriage is not so common, illegitimate unions more frequent. Mental alienation increases; suicides are more numerous. Criminality as a whole is decidedly higher.

What is the remedy? asks the collector of the ominous facts. His reply is, unceasing effort to teach men that 'life has an aim nobler than gain, higher than material enjoyment.' All will agree with the conclusion.

D. G. BRINTON.
UNIVERSITY OF PENNSYLVANIA.

SCIENTIFIC NOTES AND NEWS.

HONORARY DEGREES CONFERRED BY THE UNIVERSITY OF EDINBURGH.

WE recorded the telegraphic despatch stating that the University of Edinburgh had conferred the honorary degree of LL.D. on Professor H. P. Bowditch and Professor William Osler. The University at its medical graduation ceremony conferred the degree on nineteen persons, all of whom but two were in attendance on the meeting of the Medical Association. The complete list is as follows: Henry Pickering Bowditch, M.D., member of the National Academy of Sciences, United States of America, Professor of Physiology, Harvard University; Sir William Broadbent, M.D., F.R.S.; Thomas Lauder Brunton, M.D., D.Sc., F.R.S., Lecturer on Materia Medica, St. Bartholomew's Hospital School, London; Eugene Louis Doyen, M.D., Paris; David Ferrier, M.D., LL.D., F.R.S., Professor of Neuropathology, King's College, London; Joseph Forster, M.D., Professor of Hygiene and Bacteriology, University of Strassburg; M. le Comte de Franqueville, Officer of the Legion of Honor, member of the Institute of France; Carl Gerhardt, M.D., Professor of Medicine, University of Berlin; Richard Burdon Haldane, Q.C., M.P., Jonathan Hutchinson, M.D., LL.D., F.R.S., Emeritus-Professor of Surgery, London Hospital College; Theodor Kocher, M.D., Professor of Surgery, University of Berne; August Martin, M.D., Professor of Gynecology, University of Berlin; Johann Miculicz, M.D., Professor of Surgery, University of Breslau; Ottavio Morisani, M.D., Professor of Midwifery, University of Naples; William Osler, M.D., LL.D., Professor of Medicine, Johns Hopkins University, Baltimore; William Playfair, M.D., LL.D., Professor of Obstetric Medicine, King's College, London; Thomas

George Roddick, M.D., Professor of Surgery, McGill University, Montreal, president of British Medical Association, 1897; Siegmund Rosenstein, M.D., Professor of Clinical Medicine, University of Leiden; Herman Snellen, M.D., Professor of Ophthalmology, University of Utrecht; and Sir Richard Thorne, K.C.B., F.R.S., Principal Medical Officer, Local Goverment Board, London. In introducing Professor Bowditch, the Dean of the Faculty of Law said: "The metropolitan University of Scotland rejoices to offer her degree to one who is justly regarded as a pioneer and leader of scientific enterprise in the United States of America. The researches which the distinguished tenant of the chair of physiology in Harvard University has himself prosecuted have added not a little to the advancement of that science, notably those into the laws regulating the growth of children, the force of ciliary motion and the innervation of the vascular system. But, more than this, he has stimulated others to carry on research, and has so efficiently trained his countrymen in the most approved methods, that we are justified in largely attributing to his influence the present position of the American school of physiologists. I now beg you to confer upon the distinguished American the Honorary Degree of Doctor of Laws."

GENERAL.

THE American Association for the Advancement of Science has begun the celebration of its fiftieth anniversary as we go to press. The meeting promises to be notable and to give an impulse to the work of the Association that will last for many years. Beginning with the address of the president in this number SCIENCE will publish full reports of the meeting.

THE French Association for the Advancement of Science has just held its annual meeting at Nantes. The President, M. Grimeaux, the eminent chemist, made an address entitled 'La chemie des infiniment petits,' reviewing the work of Pasteur and his pupils. Reports were presented by the Secretary and Treasurer. The latter showed that the funds of the Association amounted to over 1,200,000 fr., and the income for the year to over 100,000 fr. More than 40,000 fr. were granted for scientific purposes.

OVER four hundred papers have already been promised for the several sections of the Association of German Men of Science and Physicians which meets at Düsseldorf from September 19th to 24th.

THE German Pathological Society will hold its first meeting at Düsseldorf in connection with the meeting of German Men of Science and Physicians. Professor Virchow is president of the Society.

THE funeral of the late Dr. James Hall took place in Albany on August 15th. The pall-bearers were Professor Lewis Boss, of Albany; Professor B. K. Emerson, of Amherst, Mass.; Professor J. C. Smock, of Trenton, N. J.; Professor William H. Niles, of Boston; Dr. F. J. H. Merrill and Professor J. M. Clarke, of Albany; Mr. G. K. Gilbert, of Washington, and Professor A. S. Bickmore, of New York. A memorial address was given in the cathedral by Father Walworth, who had been Dr. Hall's friend for fifty years.

PROFESSOR JOHN COMFORT FILLMORE, of Pomona College, California, died suddenly on August 14th, at Taftville, Conn., while on his way to attend the meeting of the American Association in Boston, where he was to have read a paper on 'The Harmonic Structure of Indian Music.' For the past ten years Professor Fillmore has been engaged in the study of primitive folk-song. Gifted with great clearness of perception, a courage that knew no fear of untrodden ground, and possessed of a thorough musical education, he was well equipped for the new problems which he met and mastered in his field of research. To him belongs the honor of inaugurating 'the ethnological method of scientific treatment of our music system,' to quote the words of a learned German authority, speaking of Professor Fillmore's work. His demonstration that the chord line, as that of the least resistance, was the line along which folk song was built, thus showing that harmony is fundamental to all music, ranks among the valuable contributions of science during recent years. A. C. F.

WE regret also to record the deaths of the

following men of science abroad: Dr. Axel Blytt, professor of botany at Christiania, at the age of fifty-four years; Dr. Carlo Giacomini, professor of anatomy in the University of Turin, on July 5th, and Dr. Ernest Candèz, the coleopterologist at Glain, near Lüttich, on June 30th.

THE will of the late Dr. William Pepper was admitted to probate on August 8th. A bequest of $75,000 as an endowment for the William Pepper Laboratory of the University of Pennsylvania was revoked by a codicil dated about two weeks before his death. The codicil is as follows: "By my said will I made a bequest of $75,000 as an endowment for the William Pepper Clinical Laboratory of the University of Pennsylvania. I have since the date of my will determined to make a gift during my life-time of $75,000 to the department of archæology and paleontology of the University of Pennsylvania for the purposes of the University Museum. Hoping at some future time to be in a position to carry out my original intention, notwithstanding my gift to the Museum, but finding it inconvenient at this time to make both provisions I hereby revoke the provision of the first paragraph of the third item of my said will." The executors state that Dr. Pepper did not have time to make this gift to the University Museum before his death, but that the desire of the family is to carry out his known wishes.

THE will of the late Adolph Sutro, of San Francisco, who during his life-time made liberal gifts to the University of California, sets aside 1,000 acres of valuable land in San Francisco for charitable and educational purposes.

MADAME PÉAN, in accordance with the wishes of her husband, has presented to the Hôpital Saint-Louis, Paris, his valuable collection of anatomical and pathological casts.

THE monument to Professor Wilhelm Meyer, the discoverer of post-nasal vegetations, will be unveiled in Copenhagen during October. An address will be made by Sir Felix Simon.

PROFESSOR W. M. DAVIS, of Harvard University, has sailed for Europe, where he will spend next year. Correspondence may be addressed care of Baring Brothers & Co., London.

DR. C. H. HITCHCOCK, of Dartmouth, has left for the Hawaiian Islands, where he expects to spend a year in geological exploration. His address will be at Honolulu.

WE noted last week that some anxiety was felt concerning the safety of the *Belgica*. Colonel de Gerlach, father of the commander of the expedition, has since made a statement to the effect that the steamship was provisioned for three years, and, though it may have got blocked in the ice, there is no cause for apprehension regarding its safety. The *Belgica* was expected to arrive at Melbourne last month, after having carried out explorations of Graham Land and Weddell See.

AT a meeting of the Council of the Royal College of Surgeons of England on August 2, 1898, it was resolved: That in view of the proposed alterations in the laws relating to vaccination now contemplated in the bill before Parliament, the Council do reaffirm the following resolution adopted by them and forwarded to the Royal Commission on Vaccination on May 11, 1893, viz: "We, the Council of the Royal College of Surgeons of England, desire to put on record at the present time our opinion of the value of vaccination as a protection against smallpox. We consider the evidence in favor of its life-saving power to be overwhelming, and we believe, from evidence equally strong, that the dangers incidental to the operation, when properly performed, are infinitesimal. Experience has satisfied us that, even when vaccination fails to afford complete exemption from smallpox, it so modifies the severity of the disease as not only to greatly reduce its mortality, but to lessen the frequency of blindness, disfigurement and other grave injuries. We should, therefore, regard as a national calamity any alteration in the law which now makes vaccination compulsory. We are, moreover, firmly convinced that revaccination is an additional safeguard and should be universally practiced. We would add that we believe that the instructions of the Local Government Board for public vaccinators are well designed to secure the greatest efficiency in vaccination and to avoid the liability to risks from the operation."

MESSRS. G. W. AND W. D. HEWITT have, as we learn from the Philadelphia *Ledger*, prepared preliminary plans for the buildings it is proposed to erect for the Philadelphia Museums. These plans are elaborate, and the structures contemplated will be enormous in size. The central building will be 208 feet square and 226 feet in height, having a central dome 100 feet in diameter. This will be known as the Administration Building. On two sides of it there will be wings, each 90 feet in width and 384 feet in length, and these will be connected by two other wings, each 80 by 300 feet, forming a hollow square. These squares will be roofed over to form immense halls or courts, 296 by 216 feet in dimensions, which it is proposed to use in connection with the other sections of the buildings for general exhibition purposes. The Administration Building, which will contain all the offices, committee rooms, library and a large assembly room capable of seating 1,500, will be six stories high, while the buildings for exhibition will be only three stories high. All the windows will be fitted with stationary sashes, and air, which has first been cleared of all dust and impurities, will be introduced by means of fans. The power house, boiler rooms, etc., will be placed along the outer line of the plot, the grade at that point being such that the boiler house roof will be on a level with the grounds of the surrounding buildings. The plans call for granite, with light gray and brick and terra cotta trimmings for the walls of the buildings, and the roofs are to be covered with slate or tile. The interior will be of fire-proof construction, plain, but substantial, especial care being given to exhibition cases and light. The proposition is to have the buildings completed in time for the exhibition, which is to take place next May.

AT the recent meeting of the National Trust for Places of Historic Interest or Natural Beauty the annual report stated, according to the London *Times*, that during the past year there had been a steady growth of membership. As the aims and objects of the Trust became better known, it was more and more referred to for help and advice in the protection and preservation of places of historic interest or natural beauty. The acquisitions of the past year had been two, each representing a different class of property. The members of the Trust had long been anxious that it should secure one of the headlands of Kent or Surrey overlooking the Weald and commanding a view of the hills, as these promontories were being rapidly purchased for building, and enclosed. During the past year that wish had been in a measure fulfilled, Mr. and Mrs. Richardson Evans and their relatives having presented to the Trust, in memory of Mr. Frederick Feeney, some land on the spur of Toy's Hill, which afforded an uninterrupted view to the South Downs. This was the first realization of the idea suggested by the Trust that memorials should sometimes take the form of beautiful scenery or of land commanding beautiful views dedicated to the memory of the dead. The adjoining piece of land on the spur had been presented to the Trust by Miss Octavia Hill. The trust had also acquired Joiner's Hall, Salisbury, an interesting old building, the impending destruction of which had too often led only to protests and vague regrets. The work of repairing the old clergy house at Alfriston was now nearly complete. A memorial stone had been erected at Barras Head recording its purchase by the Trust and its dedication to the public. With regard to Barmouth Cliff the Council regretted that the negotiations with regard to the addition of certain land to that already possessed by the Trust had fallen through. The sale of the Marquis of Worcester's Monmouthshire estate might possibly provide the Society with the opportunity of acquiring Tinturn Abbey, a piece of property of national interest. The Society hoped, as soon as the necessary arrangements could be made for their transfer, to become the trustees of the site of Driffield Castle and an old Columbarium at Garway, near Ross. The report also referred to the action taken by the Society to prevent injury and destruction, especially in regard to the St. John's Improvement and Victoria-embankment Extension Bill, the ancient camp at Uphall, near Ilford, in Essex, the Glava stones on the banks of the Nairn, Church-row, Hampstead, the old inn at Maiden Newton, the old vicarage at Luton, Christ's Hospital, the monk's barn Peterborough and several

railway projects. The statement of accounts showed a balance in hand of £191 on an income of £1,177.

THE *Elektrische Zeitung* publishes in its issues for July a long article by Dr. Zickler on telegraphy by means of ultra-violet light. According to the abstract in the *Electrical World*, it appears that he proposes a new system of wireless telegraphy, the chief object of which is to overcome the objection to the electromagnetic wave system which lies in the fact that these waves are distributed in all directions, and cannot be concentrated in one direction, all methods for doing this having apparently failed. The principle of his method, which it seems he has tried with success, is based on an observation first made by Hertz—namely, that light rays of short-wave length, especially the ultra-violet rays, have the property of promoting electric discharges—and his receiver is based on this fact. The transmitter consists of an arc light, the rays of which are condensed with lenses or reflectors into the direction in which they are to be sent, and at the receiving end the ultra-violet rays promote the discharge in a spark gap, which discharge will give rise to electric waves, which operate a coherer and through this a bell, a telephone or an ink writer; the apparatus is shown by means of diagrams. The condensing lens on the transmitter must be made of quartz, and not of glass, as the former will transmit the ultra-violet rays and the glass will not; these ultra-violet rays are shut off intermittently as desired, by means of a glass plate, which is moved rapidly in front of the camera like a shutter on an ordinary photographic camera; the ultra-violet rays will, in this way, be cut off, while there will be no apparent effect on the light rays, and for this reason the secrecy of the message will be preserved; the ordinary searchlights could be arranged to be used for the transmitter. The receiver consists of a glass tube, one end of which is made of a plate of quartz, so as to allow the ultra-violet rays to enter; these fall on a small, slanting plate in the tube, and forming one of the electrodes of the spark gap; 10 mm. from this is the other electrode, in the form of a small ball; both electrodes are mounted with platinum; the air in the tube is exhausted to a certain degree, or is filled with a rarefied gas; the electrodes are connected with the secondary of a small induction coil, the knob being the anode and the disc the cathode; the induction coil need only give a spark of 1 to 2 cm. and should be provided with an adjustible resistance for regulating the voltage, so that it will be just insufficient to produce a spark when no rays fall on the gap; whenever the rays are received a discharge will take place; a coherer in the immediate neighborhood may be used to produce a call or any other signals. If the signals are merely to be made audible a telephone in the discharge circuit is sufficient. He begins the description of the results of a very large number of experiments which he has made, mostly with crude apparatus. He found that platinum was by far the best material for the electrodes, the charge between which is to be effected by the light; the question of the best shape of the electrodes was not so easily answered, and no definite results were obtained; the air surrounding the spark gap of the receiver was exhausted to 200 mm., which gave better results; the first tests were made at very short distances, and were then increased to 50 meters, at which very satisfactory results were obtained. Some deductions are then made from this data for greater distances, and he shows how much the light must be increased with the distance; with a 25-ampere lamp provided with a suitable reflector he thinks it will be possible to telegraph in this way to a distance of a number of kiiometers; experiments with greater distances are to be carried out.

UNIVERSITY AND EDUCATIONAL NEWS.

THE London University Commission Bill has been finally passed both by the House of Commons and by the House of Lords, and London will have a teaching university as soon as royal assent has been added.

ANOTHER extremely important educational advance in Great Britain is announced in the introduction of a bill into Parliament by the government reconstructing the entire system of secondary education. There will be a comprehensive educational department presided over by a Minister of Education.

KANSAS CITY UNIVERSITY has received about $10,000 by the will of the late John Brown, of Chilhowee.

A NEW machinery building is under construction for the mechanical department of the University of Tennessee. The University lights its own buildings and the increased demand for light will be met by a direct connected generating set placed in the new machinery building. The machine shops will also be driven by electricity from the same plant, doing away with all belting and line shafting. The new building will also contain an electrical testing room for such tests as cannot be made at the laboratories of the electrical engineering department. The old machine shop is being rebuilt to furnish an additional dormitory.

THE Commissioners for the Exhibition of 1851 have made their appointments to science research scholarships for the year 1898 on the recommendation of the authorities of the respective universities and colleges. The scholarships are of the value of £150 a year, and are ordinarily tenable for two years (subject to a satisfactory report at the end of the first year) in any university at home or abroad, or in some other institution approved of by the Commissioners. The scholars are to devote themselves exclusively to study and research in some branch of science the extension of which is important to the industries of the country. A limited number of the scholarships are renewed for a third year where it appears that the renewal is likely to result in work of scientific importance. Five scholars have been appointed for a third year, seventeen have been appointed for a second year, and thirteen new appointments have been made. Three of the scholars will work in the United States, one at Harvard, one at Cornell and one at Columbia.

A BILL has been introduced into the British House of Commons forbidding anyone to attach to his name a degree obtained abroad, without giving the source from which it has been received.

FROM official statistics published by the Minister of Public Instruction and summarized in the *British Medical Journal* it appears that on January 15, 1898, the total number of students in the faculties and schools of superior instruction in France was 28,782. Of this number 27,911 were men, 26,419 being French, and 1,492 foreigners; and 871 were women, of whom 579 were French and 292 foreign. The total number of students in the several faculties and schools of medicine was 8,064, of whom 399 were women; of the whole number 734 male and 168 female students were foreigners. The 'extra-legal' schools of medicine outside the universities had 949 students, of whom 70 were women; while the medical schools at Algiers had 763, of whom 24 were women. There are in Paris 11,647 students, of whom 3,971 are students of medicine. Next to Paris in respect of student population comes Lyons, with 2,335, of whom 1,106, including 33 women, belong to the medical faculty. Bordeaux occupies the third place, with 2,144, of whom 737 are students of medicine. Toulouse, Montpellier, Lille, Rennes and Nancy have each over 1,000 students.

DR. JOHN C. THRESH has been appointed lecturer on public health at the London Hospital Medical College new laboratories, and a public health museum will be opened at the College at the beginning of the next session.

DISCUSSION AND CORRESPONDENCE.

AN AMERICAN BLUE GROTTO.

MANY of the beautiful phenomena seen at the celebrated Blue Grotto of the island of Capri are reproduced on a small scale in a cavern at Lake Minnewaska, New York. This lake is situated on the Shawangunk range of mountains at an elevation of about 1,700 feet; it lies in a basin, excavated in glacial times, about half a mile long and less than a quarter in width, and of a depth reaching seventy feet. The rock on all sides is a white quartzite known as Shawangunk grit, which rests upon shale, but no outcrop of the latter is visible at the lake. The quartzite is compact to granular and contains in places pebbles of white quartz; it is very free from feldspathic admixture, so that it yields to the water very little soluble matter. Bare cliffs rising to the height of 150 feet bound the east side of the lake, while the western banks

are well wooded. The cliffs are vertical and fringed at their base by the usual talus, which, however, is made up of blocks of unusual size. The cavern is formed by several huge rocks overhanging the water so as to form a comparatively dark hole, and the space between the under side of the sloping rocks and the water varies from about two feet to not more than two inches. The cavern faces the southwest; it is very irregular in shape, and at one point the roof and walls reverberate in response to a deep bass note. The water just at the entrance to the cavern is 33 feet deep, and two or three feet away 40 feet; it is very transparent at considerable depths. As the rocks overhang so close to the water the optical effects can only be seen by a swimmer, and it was while swimming along the shore that I discovered the American Blue Grotto three years ago. As one approaches the mouth of the cavern the bluish color of the water is noticeable, but the beautiful effects are best seen by entering the opening and looking outwards towards the light. The water varies in color from Nile green through turquoise blue and sky blue to deep indigo blue, and in all these shades exhibits the silvery appearance, when agitated, characteristic of the grotto at Capri. A body immersed in the water has a beautiful silvery sheen, similar to the reflection of moonlight. The water has these colors at all hours, but they are strongest when the sun is in the zenith; late in the afternoon the slanting rays of the sun enter the opening and light up the cavern, greatly diminishing the optical effects.

The water retains the characteristic color (but without the silvery sheen) on cloudy days, and even during rain, being especially strong when fleecy white clouds bar direct sunlight. The relation between the different hues, green and blue, to the aspects of the sky, whether clear or overcast, is not evident.

Another pleasing phenomenon must be mentioned. Just below the water line, where the rocky sides are lapped by the waves, the white quartzite exhibits a brilliant siskin-green hue; this bright color is limited to a space about three or four inches below the level of the lake and to certain walls of the cavern. The bare arm immersed in the water partakes of the green color when the light is reflected at one angle, and of the silvery blue color at another angle. The interior size of the cavern is not easily given, but the face of the overhanging rocks measures about 40 feet and they project about 15 to 20 feet, and it is surprising that so small a cavern can produce such a variety of fine effects.

The writer would like to learn, through the columns of SCIENCE, whether similar blue grottos are common at other American lakes.

H. CARRINGTON BOLTON.

LAKE MINNEWASKA, August, 1898.

'THE DELUSION OF ATAVISM.'

DR. BRINTON'S recent remarks on the 'Delusion of Atavism' recall Dr. Thomas Dwight's paper on the 'Range and Significance of Variation in the Human Skeleton,' a paper which may be read with much profit by those who are bound to find some reversional character in every anatomical abnormality. As Dr. Dwight says, "if all animal resemblances are reversions, the primitive ancestor must have been a very curiosity shop of peculiarities."

F. A. L.

SCIENTIFIC LITERATURE.

Technical Mycology. By DR. FRANZ LAFAR. With an introduction by DR. E. CHR. HANSEN. Translated by CHAS. T. C. SALTER. Vol. I., Schizomycetic Fermentation. London, Chas. Griffin & Co., Ltd.; Philadelphia, J. B. Lippincott Co. 1898. Pp. 405, with 1 plate and 90 figures.

The appearance last year of the first volume of Dr. Lafar's *Technische Mykologie* relating to fermentations induced by Schizomycetes marks the gradual development of bacteriological science along other than medical lines. The interest that is attached to the study of these micro-organisms in other than their pathological relations is rapidly increasing, and we may hope that such works as these will stimulate investigation and study in a very promising field of research. The translation of this work into English by Salter will unquestionably be welcomed.

The scope of the work is the utilization of micro-organisms in the arts and manufactures.

The present volume includes those processes that are induced by bacterial organisms. A prospective volume will take up such changes as are caused by the higher fungi.

While the general purpose of the present text is to consider bacteriology in its applied phases (other than medical), still the general biological student will find much that will interest him. The exceedingly well-proportioned and thoroughly digested chapters on the historical development of bacteriology, as well as the general biology of bacteria, will be appreciated by all biologists. Technical chemists, fermentation physiologists and students of agricultural bacteriology will also find the book a great help in their work.

One striking feature of the work is the thoroughness with which the literature has been sifted. Dealing as it does with such a diversity of subjects, the labor of gathering the data from a multitude of technical as well as scientific journals has been very considerable, and the successful manner in which this has been accomplished adds materially to the value of the work.

It seems incredible, however, that the translator should allow the book to be presented to English readers without an index, even though the original lacked this necessary adjunct to usefulness. Another undesirable feature is that the copious bibliographical references are not to appear until the second volume is published, thus handicapping the utility of the book for a considerable time at least.

H. L. RUSSELL.

The Story of Extinct Civilizations of the East. By ROBERT E. ANDERSON, M.A., F.A.S. New York, D. Appleton & Co. 1897. 12 mo. Pp. 213.

We have here a useful little book, compiled with more knowledge and discretion than are usually discoverable in such pot-boilers. The author takes up in turn Babylonia, Egypt, the Hittites, Phenicians, Arabs and ancient Persians. He chooses his authorities judiciously, not being either tedious or frivolous.

The introductory chapter on the 'Origin and Races of Mankind' is the least satisfactory of the volume. He prefers Cuvier's classification into three races, on the color line, which has never been accepted outside of France and is inadequate to our present knowledge. He uses 'race' in the loosest senses, 'white race,' 'Aryan race,' Slavic race,' etc. But these are slight blemishes, and inappreciably mar the merit of the whole.

D. G. BRINTON.

Nests and Eggs of North American Birds. By OLIVER DAVIE. Fifth Edition, Revised, Augmented and Illustrated. Columbus, 1898.

The first edition of this book, issued in 1885, comprised but 77 pages of pica type; the present issue contains over 500 closely printed pages. While devoting particular attention to the nesting habits and eggs of North American birds, the book contains a large amount of information concerning the distribution and life histories of birds and includes a chapter on ornithological and oological collecting. Although current ornithological literature has been freely drawn upon by the author, he has also availed himself of the work of a large number of active field ornithologists who have placed at his disposal their notes on the eggs, nests and nesting habits of various species. The full citation of the numerous authorities adds greatly to the value of the work, which should retain the popularity accorded it since its first appearance.

F. A. L.

NEW BOOKS.

Psychology for Teachers. C. LLOYD MORGAN. With a Preface by HENRY W. JAMESON. New York, Charles Scribner's Sons. 1898. Pp. xi+240. $1.00.

Proceedings of the Society for the Promotion of Engineering Education. Vol. V. Published by the Society. 1898. Pp. xxii+337.

New York State Museum.—Fiftieth Annual Report of the Regents. 1896. Vol. I., Report of Director, Botanist and Entomologist. Albany, The University of the State of New York. 1898.

Special Report of the U. S. Department of Agriculture on the Beet Sugar Industry in the United States. Washington, Government Printing Office. 1898. Pp. 230.